RADIATION PROTECTION OPTIMIZATION CHECK ON RADIO DIAGNOSTIC EQUIPMENT OF RADIOLOGY UNITS OF SOME HOSPITALS IN ZARIA, KADUNA STATE.

By

GODFREY LAWISSENSE DUNAH

DEPARTMENT OF PHYSICS
FACULTY OF SCIENCE
AHMADU BELLO UNIVERSITY ZARIA
NIGERIA

OCTOBER, 2014

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Godfrey Lawissense DUNAH, B.Sc(ED) (A.B.U)2002
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DEPARTMENT OF PHYSICS
FACULTY OF SCIENCE
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA.

OCTOBER, 2014

DECLARATION

I hereby declare that this thesis entitled "Radiation Protection Optimization Check on Radiognostics Equipment of Radiology Units of some Hospitals In Zaria, Kaduna State" has been written by me and that it is an account of my own research, except that for reference to other peoples work which have been duly cited. No part of this thesis was previously presented for another degree or diploma at this or any Institution.

Godfrey Lawwissence Dunah	Signature	Date

CERTIFICATION

This thesis title: ra**diation Protection Optimization Check On Radiodiagnostics Equipment Of Radiology Units Of Some Hospitals In Zaria, Kaduna State** by Dunah Godfrey Lawissence meets the regulations governing the award of master of science (M.Sc) of Ahmadu Bello University Zaria and is approved for its contributions to scientific knowledge and literary presentations.

Dr D.J. Adeyemo (Chairman, Supervisory Committee)	_____ Signature	_____ Date
Dr U. Sadiq (Member, Supervisory Committee)	_____ Signature	_____ Date
Dr U. Sadiq (Head of Department Physics)	_____ Signature	_____ Date
Prof A.Z Hassan (Dean, School of Postgraduates Studies)	_____ Signature	_____ Date

DEDICATION

I dedicate this piece of work to God Almighty and to my children Divine Falda Godfrey and Samuel Hyelmupuda Godfrey

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Abstract

Radiation Protection Optimization Check on radiodiagnostic Equipment Radiology Units has been an important tool in clinical medicine. The physical operation of the X-ray equipment is one of the most important parameter in quality control (QC) check in radiology department, because there could be no well-designed radiation protection programmes for the hospitals especially the un-purposed build. Where a poorly structured programme exist, there may not be proper examination of the programme to access its adequacy and relevance incomparison to the ideal program recommended by International Commission on Radiology Protection (ICRP). This research work is set to examine the existing radiation protection program in the selected hospitals, to encourage hospitals to have identified data base and develop it for future appraisal. To recommend a compete QA/QC that is appropriate for the optimal functioning of radiaodiagnostic equipments in the selected hospital. QA/QC kits was used for check on five (5) hospitals, the result obtained were compared with standard acceptable limit. The parameters checks include, kVp output consistence, collimator and beam alignment, film screen contact, focal spot, grid alignment and half value layer (HVL). The result obtained for hospital A shows complete compliance to the acceptable limit set by NNRA/ICRP. In the areas of kVp, the tolerance limit is within ±5%, collimator and beam alignment, misalignment was within 0.5^0 -1.0^0, grid alignment shows symmetrical decrease in the radiation intensity, HVL at 80 kVp ≥2.5mmAl. while for hospitals B,C,D and E the result obtained for kVp tolerance limit was outside range, collimator and beam alignment was within 2.5^0-3.0^0 outside range grid alignment shows no symmetrical decrease though the HVL reminds within range. From the result obtained except for hospital A that shows adherence to guidelines, the remaining hospital B, C, D and E varying levels where evidence with no hospitals demonstrating complete compliance to NNRA/ICRP standard guidelines that is needed to

avoid retakes. Recommendation and conclusion where drawn on hospitals that shows variance to acceptable quality control programmes, thus hospitals should be made to do routine QC checks on their radiodiagnostic equipment.

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LIST OF ABBREVIATION

QA/QC	Quality Assurance/Quality control
ALARA	As Low As Reasonable Achievable
HVL	Half Value Layer
SID	Source to Image Distance
FFD	Film to Focus Distance
MA	MiliAmpere
mAs	Miliampere Second
mR	millirem

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Radio diagnostic equipment has been an important tool in clinical medicine. Most clinical crucial problems these days depend on radiological analysis. The process of generating a good medical image involves the skill on the part of the technicians/radiographers, the sensitivity on the part of dark room attendants and, optical functioning of the equipment .When the above three factors are adequately taken care of, quality can be assured, control of unnecessary/unwanted rejects of developed films and hence optimization of radiation protection will be achieved. In the many years of practice of imaging as a medical discipline, radio diagnosis has grown from plain radiography to a number of contrast aided techniques using image intensified fluoroscopy, Computed Topography (CT), ultrasonography, ultrasound Magnetic Resonance Imaging etc.(P.P. Dendy and Heaton,1999).

Modern equipment allows lesser dependence on the operator because of increased automation; however, unfortunately most radiographic techniques in the third world are still operator dependent and many machines do not have a micro processor-controlled circuitry and hence resulting in greater incidence of malfunction. (Rahani, 1995).If radio diagnostic equipment qualities are not checked and controlled for optimal result there could be an unnecessary and unwanted over exposure of patients, workers and general public to the potential hazards of ionizing radiation. In the operational radiation protection in hospitals, optimization process which is one of the three principles of radiation protection (the other two are justification of usage and dose limitation) programme and practices is to keep exposure to radiation as low as reasonable achievable (ALARA Concept) economic and

social factors being taken into account (IAEA 1990).With this, detriment from a radiological practices should be reduced by protective measures to level, such that further reduction becomes less significant than the additional efforts required for their implementation (IAEA 60; 1990).In ensuring that requirements of the output of a process are met, cost is involved such cost may be from the establishment of procedures, training and retraining, purchase of appropriate technology, monitoring of processes, maintenance etc.

A good radiation protection optimization check on radio diagnostic equipment of radiology units is quality assessment /quality control (QA/QC) of the equipment which generates the radiation. This work will look at QA/QC in radio diagnostic equipment of some hospitals located in Zaria, Kaduna State, with the main aim of evaluating some important performances of the equipment comparing them with goals and acting on the differences if any.

1.2 Statement of the Problem

With the increase in use of radio diagnostic equipment in clinical medicine, and the known effect of radiation on man and environment it is important to look at the radiation protection optimization practices in purposed and un-purposed built hospitals because;

(a) There may be no well-designed radiation protection programme especially for the un-purposed (mainly private) hospitals, which is the initial step in the optimization protection processes. It is very important to have a programme appropriate to the kind of hazard that could be associated with operations.

(b) In some organization, where a poorly structured programme exists, there may be no proper examination of the programme to access its adequacy and relevance in

comparison to the ideal program recommended by International Commission on Radiological Protection (ICRP).

(c) There could be no adequately identified database for future evaluation. That means the optimization process is difficult to access due to either lack of information or information not properly recorded for future use. A well defined database will enhance any future optimization and appraisal.

(d) There could be no feedback proposal. To have perfect optimization of a complete operational system, feedback proposal is an essential mechanism to ensure that the application of radiation protection program and the lessons learnt are documented for subsequent future optimization studies.

(e) There could be no practical guidance to the management of radiation protection programmes, especially in the un-purposed built hospital in Zaria metropolis.

(f) There could also be no identified standard for ensuring and maintaining quality in radio diagnostic equipment in the radiology departments of most of the selected hospitals.

1.3 Aims and Objectives of the Study

It is obvious that the operational radiation protection program vary differently based on either scale or complexity. The main aim of this research is therefore to check QC on radio diagnostic equipment in radiology department of some hospitals in Zaria. In view of the above stated problems, it is important that the optimization should follow a well defined pattern as recommended by ICRP. This work is therefore set out to achieve the following objectives.

(a) To examine the existing radiation protection program (if existed) in the stated hospitals to find out all the differences that may be significantly shown between the

ideal and these programs, considering weight, omissions, etc. where necessary emphasis will be laid.

(b) To encourage hospitals develop data base for future appraisal.

(c) To ensure that guidelines for the protection of man and his environment from harmful effects of ionizing radiation are provided.

(d) To recommend a complete QA/QC checks that is appropriate more especially for the optimal functioning of the radio diagnostic equipment if needed in the radiology units of the selected hospitals in Zaria.

(e) The factors used for the evaluation of QA/QC in standard hospitals would be adopted for local units and be quantified.

1.4 Justification of Research Work

The principles and practices to be outlined in this work and their applications will ensure that no radiology practice resulting to unnecessary and unwanted over exposure to ionizing radiation would be authorized by the relevant competent authorities unless its introduction and application produces a positive net benefit. There are many factors that play a role in operational radiation protection and optimization which have a marked effect on the total radiation detriment of an individual.

The justification and relevance of this work is in the reduction of the negative component of radiation effects to the patients, workers, general public and the environment. The reduction of these negative components will arise because of the reduction in the over exposures due to:

(a) Near absence of repeats.

(b) Low exposure from the reduced scatter (secondary) radiation.

(c) Check leakage in the x-ray tube.

All these could be achieved when the optimal functioning of the equipment is achieved.

To the best of my knowledge, this work especially using un purposed hospitals in Zaria, work has been done, so it is hoped that very significant contribution to knowledge will be made by its outcome.

1.5 Scope and Limitation

This study will focus on the radio diagnostic equipment/facilities that will be found in the selected radio diagnostic Centres in Zaria metropolis. The hospitals to be considered for this work include:-

(a) Ahmadu Bello University Teaching Hospital (ABUTH) Shika, Zaria

(b) Saye Leprosy Hospital, Zaria

(c) Jalva Radio diagnostic Centre, Zaria

(d) Pal Hospital, Zaria

(e) Tukur Tukur Medical Center, Zaria

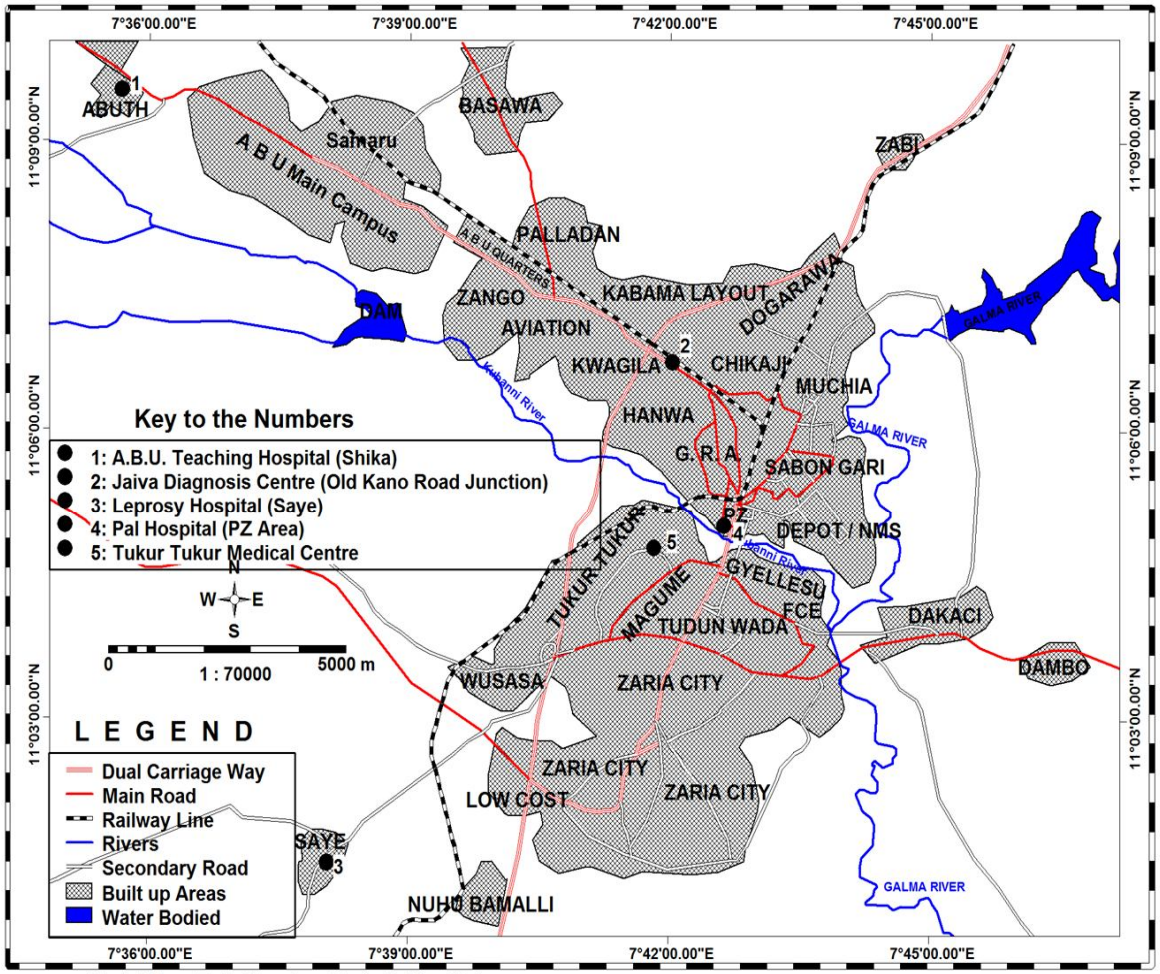


Fig 1: Urban Zaria Showing Strategic Hospital.
Source : Department of Geography Federal College of Education, Zaria (2013).

Map of the study area showing locations of the interested hospitals.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Natural Radiation

All elements found in natural sources with atomic number greater than 83 (Bismith) are all radioactive materials. Many radioactive nuclides do not become stable nuclei through just one decay but their daughter nuclei are also radioactive. The daughters continue to decay until they arrive at a stable nuclide. This is called cascade decay Cember (2004). There are three cascade decay chains found in nature the fourth one is a series whose initial parent ^{237}Ne (neptunium) is too short lived for the chain to be found in nature. $\left[^{237}Np\ \left(T_{\frac{1}{2}} = 2.20 \times 10^{6} years\right)\right]$ which is less than the age of the Earth which is approximately 3×10^{9} years.

Its final stable Isotope is ^{209}B. These four series are; Thorium, Neptunium, Uranium and Actinium. (Cember, 2004). Each of the three naturally occurring series begins with an isotope whose half-life is of the order of billions of years or more than the time compared to the age of the Earth.

The decay of radioactive isotope can only be detected for about 10 half-lives. Therefore, to be observed in nature an isotope must have a half-life not shorter than one tenth $(1/10)$ of the age of the earth or be continuously produced by the decay of such a long lived isotope or by some nuclear reaction that continues to occur in nature.

2.1.1 Terrestrial Radiation

These are radiation exposures to man from the natural radioactivity that take place in the walls of the buildings, soil, water and trees within man's environment. This type of radiation is obtained from long-lived radio-nuclides which were produced in the processes

that occurred when solar system was formed. The natural radio nuclides in the earth, soil and water in the environment are present as daughters of Uranium (^{238}U), Thorium (^{232}Th) and Potassium (^{40}K) Glenn Knoll (2000). Exposure to excess level of background ionization radiation can cause somatic and genetic effects that can lead to damage of crucial cells in the body.

2.1.2 Cosmic Radiations

These are radiations from the outer space. They are categorized into two sources, which are galactic and solar sources. These radiations reach the earth from outer space and from the sun; most of these radiations (photons, alpha, electrons, and heavy charged ions) do not reach the sea level, but interact with high energetic particles in the atmosphere. The interaction between the primary cosmic radiation and atomic nuclei in the atmosphere lead to the formation of Secondary Cosmic Radiations (mesons, electrons) most of which reach the sea level. These mesons masses are greater than those of electrons but less than those of protons. About 80% of Secondary Cosmic Radiations are Mesons and 20% electrons. Cember (2004).

(f) Natural Background Radiation (uncontrolled radiation)

i. Cosmic rays – 0.5 mSv/yr (Glenn Knoll, 2000 and Nzotta, 2007).

2.2 Artificial Radiations:

Until 1934, the naturally occurring radioactive substances were the only ones available for study. In January of that year I Curie (daughter of Pierre and Marie Curie) and F. Joliov announced that Boron and Aluminum could be made radioactive by bombardment with the α-rays from polonium. This discovery of artificially produced radioactivity came in the course of their experiment on the production of positrons by bombardment of these elements with α-particles. The positron had been discovered two years earlier by C.D.

Anderson (1934) as a component of the cosmic radiation, (positron is much like the electron but positively charged). Many laboratories then followed and found that positron could be produced in light elements by α-ray bombardments.

The discovery of the neutron by I. Curie and F. Joliot in 1932 and the isolation of deuterium by I. Curie and F. Joliot in 1933 made available two additional bombarding particles that turned out to be especially useful for the production of induced activities. Thirty (30) years after Curies and Joliot's discovery there was rapid growth of the new field. Within three (3) years the number of known artificially produced radioactive species reached two hundred (200). Within 20 years it got to about 10000 and by 1938 the number was over 2,5000 with new species still being reported almost every month Cember (2004). The measured half-lives range from microseconds to many millions of years. The discovery of nuclear fission by O. Hahn and F. Stresemann in 1938 gave further strong input to the study of new radioactive products. The subsequent development of nuclear chain reactions opened the way for the production of many radioactive substances (isotopes) in large quantities and also their widespread application in many fields such as chemistry, physics, biology, medicine, agriculture, engineering etc. Nzotta (2007)

Artificial radioactivity has been spread throughout the world as a result of atmospheric nuclear weapons testing (now largely discontinued).The radioactive debris injected into the stratosphere has deposited on the earth surface, on soils and crops. The fallout radio-nuclides can be inhaled directly or taken up through food chain. These processes cause internal exposure. Radio-nuclides that emits gamma rays, when deposited in soil can cause external exposure. (Yusoff et al, 2001).

The second most common type of radiation source used in industrial radiography is the X-ray. Unlike gamma radiation which are emitted from radioactive material, X-rays of sufficient intensity for industrial radiography are produced by a machines which can be turned on and off at will. X-ray sets in hospitals and clinics are probably the best known source of artificial radiation.

(g) Natural background radiation which is termed controlled (Artificial Source of Radiation

i. Medical Exposure -about 0.05mSv/yr

ii. Nuclear industry fallout -<0.01mSv/yr

iii. Occupational Exposure -<<0.01mSv/yr

iv. Others -about 0.01mSv/yr(IAEA, 2010)

The occupational exposures involved in hospitals constitute the whole body doses, and the average dose received from the natural background is unavoidable. Medical exposures are justified from the medical point of view, since the benefit to the exposed person far outweighs the risk (IAEA, 1990, AMPI, 1997). However, the unnecessary and unwanted over exposures that could also arise due to medical diagnosis are not justified and so should be checked.

The above measurement depends on the location, thus the total of natural background radiation could be about 2 mSv/yr. In some countries, like India it may be greater than 2 mSv/yr. (ICRP, 2000).

(h) Controlled (man made) Source of radiation

i. Medical exposure - about 0.03 mSv/yr

ii. Nuclear Industry fallout - < 0.01 mSv/yr

iii. Occupational exposure - <<0.01 mSv/yr

iv. Others - about 0.01 mSv/yr(IAEA, 2010)

2.3 Types of Radiation used in Radio diagnosis – X-rays

X-rays are photons, or electromagnetic radiations produced by the collision of electrons with atoms of the target mediums Cember (2004) .

2.3.1 X-ray Production

When a beam of monoenergetic electrons that had been accelerated across a high potential difference is abruptly decelerated by stopping the electron beam (as in the case of an X-ray tube, a cathode ray tube, or a klystron microwave generator), a small fraction of the energy in the electron beam is converted into X-rays Nzotta (2007)

$f_e = 1 \times 10^{-3} \times ZE$ …….. ……... 2.1

where

fe = fraction of the energy in the electron beam that is converted into X-rays,

Z = atomic number of the target in the X-ray tube or whatever the electron beam strikes in any other device, and

E = voltage across the X-ray tube.

The operating principle of traditional diagnostic, industrial, and analytical X-ray tube is shown in (Fig. 2.1) below.

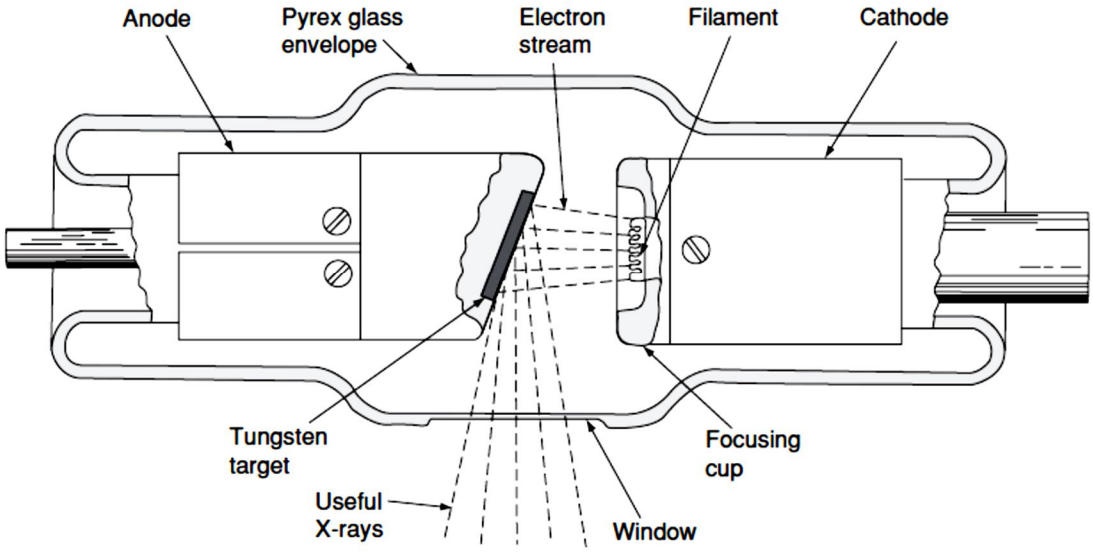


Figure 2.1: Coolidge type stationary target X-ray tube by American Physicists William D. Coolidge, 1913, (Cember, 2004).

An electron beam, usually on the order of milliamperes, is generated by heating the cathode. A voltage difference on the order of tens to hundreds of kilo volts across the tube accelerates the electrons to form a mono energetic beam in which the kinetic energy of the electrons in electron volts is numerically equal to the voltage across the tube. The high-speed electrons are stopped by a high-atomic-numbered metal target

In X-ray generators where the voltage is less than several hundred thousand volts, the X-rays (photons) are emitted mainly at angles around 90◦ to the direction of the electron beam. A hole in the protective shielding that houses the X-ray tube allows a useful X-ray beam to emerge from the shielded tube.

The X-rays that are produced in this manner have a continuous energy distribution that approaches a maximum energy equal to the kinetic energy of the electron that was stopped instantaneously and thus have all of its kinetic energy converted into an X-ray photon Cember (2004). If an electron were to be instantaneously stopped by the target, all of its kinetic energy would be converted into an X-ray photon.

Therefore, X-rays are produced by bombarding the target medium or particle by accelerated electrons in an X-ray tube, it emit continuous radiation with varying energy from 1KeV to a maximum potential peak intensity of the applied kVp.

X-rays are therefore produced by energy conversion, when a fast moving electron is suddenly decelerated in the target of an X-ray tube.

The X-ray quality produced is proportional to the atomic number of the target medium, the square of the kVp or $(kVp)^2$, the mill amperes (mA) and time(s) P.P Denddy and Heaton (1999)

Thus $Q\ \alpha\ n(kVp)^2 mAs$…… 2.2

Where Q = X-ray quality produced

n= atomic number of the target

kVp= Voltage Potential

mAs= Milliamperes second

2.3.2 Properties of X-ray

(i) Photographic effect:

X-rays produce latent image on photographic film which can be developed to give a visible film as seen on an ordinary photographic negative. Although a radiographic film is most often used in a cassette containing a pair of fluorescence intensifying screen. Only about 5% of the image is formed by the direct action of X-ray, the remaining 95% is due to the visible and ultra-violet light emitted by the intensifying screen to which the film is more sensitive (Denddy, 1999).

(ii) Penetration Effect

X-rays penetrate substances that are opaque to visible light, its penetration is gradually absorbed by the substance it passes through. The amount of absorption depends on the atomic number and the density of the material medium and on the energy of the X-ray. Thus, diagnostic radiology depends on the differential absorption of radiation of various tissues. (Allison, 1968).

(iii) Ionization and excitation effect:-

X-rays cause excitation and ionization of atoms and molecules of substance through which they pass. The bases of all x-ray interaction with matter depend on ionization and excitation. Thus, the best method of measuring quantity of X-ray radiation or exposure is by ionization Cember (2004).

(iv) Chemical Changes:

X-rays causes chemical changes in substance through which they pass and can result in cell damage or destruction Jurgen Kiefer (1989).

(v) Biological Effect:

The biological effect of X-ray is produced by either direct or indirect action. Direct action on the cell or indirectly as a result of chemical changes around this cell, then the cells can either be damaged or destroyed.

2.4 Effects of Radiation

Early human evidence of harmful effects of radiation to man as a result of its exposure existed long enough. The early radiologists and special occupational workers experience skin burn, erytheme, epitation amongst them (Cember, 2004).

Today, epitation is common among cancer patient who undergo prolonged radiation therapy. The experience from prolonged x-ray produced on for example skin burn directly

on the individual exposed is called *somatic effects* while those that are transferred to the victim's offspring are called *genetic effects.* This radiation effects can be classified into two categories Cember (2004), which are

- Stochastic (Probabilistic)
- Non-stochastic (Deterministic)

2.4.1 Stochastic Effects (Probabilistic Effects)

Stochastic effect, are effects that occur randomly without a threshold level of dose and in which the severity of the damage is relatively independent of the size of the dose responsible for it. The relationship between dose and effect is probabilistic. The predominant stochastic effect is the induction of cancer while the severity of the individual cancer does not increase, there is a probability that a larger and larger proportion to the exposed population may develop malignancy Jurgen Kiefer (1989). These effects are further classified into somatic and genetic effect. Somatic effect manifest within the lifetime of the person where the genetic effects manifest in the succeeding generations Cember (2004).

2.4.2 Non-Stochastic Effects (Deterministic Effects)

Non-Stochastic effects are those effects to which there exists a threshold dose. The severity of these effects increases with dose and involves a large number of cells. For example, cataract, life shortening etc. (Jurgen Kieffer, 1989).

2.5 Principle of Radiation Protection

In deciding on safe level for any radiation worker, the following guiding principles should be considered:-

(a) Prevention of deterministic effects by not reaching or crossing the threshold values.

(b) Limiting the probability of stochastic effects to levels deemed to be acceptable by using ALARA principle.

The above guiding principles lead to radiation protection principles.

2.5.1 Justification of Practice

No practice involving radiation will be adopted unless its benefits outweigh the risks to the individuals and the society.

2.5.2 The optimization of protection

All radiation exposure shall be kept as low as reasonably achievable (ALARA) economic and social factors taken into account. The level of protection that meets the requirement involves many components. These components involve the principle of an evaluation of all the alternative options of protection and their consequences in the hospitals. Thus, the main procedure of optimization should include:

(a) Identify radiological problems

(b) Identify alternative protection options

(c) Apply decision aiding technique

(d) Optimize

The purpose of the above procedure is to establish and clarify the problems that is obtained with the aim of solving them and properly assessed the alternative radiological protection options, method applied and their consequences. In general optimization procedures focuses on dose equivalent. It is very important to note that other considerations can take

precedence i.e. when the total harm is dominated by a contribution arising from the exposure of large group at low level of individual doses, it covers the contributions from a small group that are close to authorized limit.

A better radiation protection therefore can be achieved when an appropriate balance between the magnitude of individual doses and the overall collective dose is obtained.

2.5.3 Individual Dose limit

The equivalent doses to individual resulting from the above practice should be subjected to the equivalent limits. To ensure that no individual is exposed to radiation risks that is unacceptable in normal circumstances.

The above radiation principle implies that there are some risks which are justifiable in comparison to the benefits expected. Thus, the amount of radiation which result in an acceptable level of radiation which is known as maximum permissible dose (MPD) is 20 mSv/y averages over the period of five years for classified radiation workers. Cember, (2004).

The principle put in place to effect this optimization include:-

(i) Minimizing exposure time

The radiation absorbed dose (D) is equal to Dose rate multiple by time Cember (2004)

$D_{AB} = D_R \; x \; t$ …….. 2.3

i.e. the longer the time spent in the radiation field, the greater the dose received.

Where D = Absorbed Dose

$\dot{D}$ = Dose rate

t= time

If the time required for one person to complete an assignment in a radiation field it will result as over exposure, then the work procedure should be planned so that minimum amount of time is spent to complete the assignment by individual. (IAEA, 60, 1990) i.e. more people should get involved to reduce the exposure to individuals and thus sharing the dose.

(ii) Maximizing distance from radiation source

The intensity of radiation decreases with distance from source. When radiation is emitted from source, it travels uniformly in space, so the total emission can be considered as uniformly distributed over a sphere of radius r. Hence, the dose (D) at this distance 'd' in metres is inversely proportional to the square of the distance Oudiz et al, (1997).

$D \propto \frac{1}{d^2}$. (Inverse square law) ……..... 2.4

(iii) Shielding

A shield is a medium of such a thickness which can attenuate radiation but may not stop it's passage completely. The effectiveness of the shields is determined by the type of interaction between the radiation type and the action of the absorbing medium i.e. the interaction depends mainly on the radiation type (α, β, γ, x-ray), the energy and the atomic number of the absorbing medium.

Thus, for shielding Cember (2004)

$I = I_0 e^{-\mu x}$ …… 2.5

Where I_o = initial intensity

I = field intensity of the radiation

μ = attenuation coefficient

x = thickness of the material.

Also for quick shield estimate, half value layer can be used Cember (2004)

$X_{\frac{1}{2}} = \frac{0.69}{\mu}$ 2.6

where $X_{\frac{1}{2}}$ = the thickness of material which reduces the initial intensity to half of its original value.

μ = attenuation coefficient

To determine the number of fractional value layer needed to reduce the initial intensity to any desired level, this equation should be used.

$X_{\frac{1}{2}} = \frac{\ln(n)}{\mu}$. (Cember, 2004). 2.7

Where *n is the number of fractional value layer needed*

2.6 Quality Assurance in Diagnostic Radiology: Concepts and Practice

The process of generating a good medical image mainly involves three factors which are skill on the part of the technician/radiographers, the sensitivity on the part of dark room attendant and the optimal functioning of the equipment. Therefore these three factors have to be adequately taken care of for quality to be assured without rejects or retake that may lead to unnecessary and unwanted exposure.

It is only in an ideal situation that the three factors are present and fully controlled. In practical situations all the three may be lacking. These factors affect image quality assessment needed for diagnosis and treatment. The films produced are classified into A, B or C grades.

Where:

A = Acceptable without any reservation.

B = Acceptable with some reservation/remarks

C = Reject quality.

The decisions on grade are solely based on the radiologist reporting the film.

Many factors affect the quality of the image and since these factors are largely independent, fault in any single factor will affect the final image quality.

2.6.1 Quality Control (QC)

This comprises the qualitative or quantitative measurements or test or performance of an instrument or program and the determination of adequacy and acceptability of performance. This diagnostic procedure covers monitoring, evaluation and maintenance of optimum levels of all characteristics of performance that can be defined, measured and controlled. (Rahani, 1995).

2.6.2 Quality Assurance

The application of a service of quality control steps at multiple stages of a procedure to verify that all aspects of the procedure are of acceptable quality. “Quality is conformance to requirement verify”.

2.7 Quality Assurance Program

A QA program will identify the parameters to be monitored and the frequency of the tests and this should include:-

2.7.1 Recording of result

The x-ray unit should have a log book and the results of periodic QA test recorded in it and it should also contains the record of service on the equipment.

2.7.2 Performance evaluation test

These should be classified into mechanical, radiological and other test e.g.

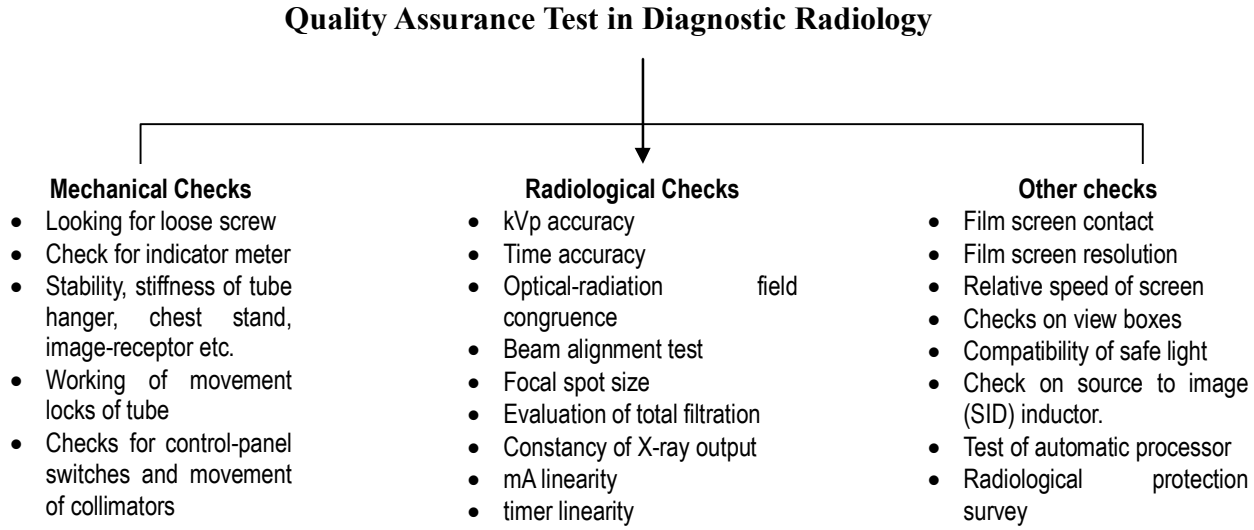


Figure 2.2: *Quality Assurance Test in Diagnostic Radiology,* **(Rahani, 1995)**

2.7.2.1 Mechanical Checks/Assessment of the Physical X-ray Operations

The physical operation of the X-ray equipment is one of the most important parameters in Quality Control (QC). The evaluation check on the integrity and stability of mechanical working of different facility of an X-ray machine include, looking for any loose screws or bolts, perpendicularity of tube to the table surface, check for regulating lamp of x-ray, regulating light of the bulky, malfunctioning or non-functioning indication, meters and pilots lights, padlocks, the grid grooves and x-ray linearity maximum Inherent filtration, generator type. Checks for stability and stiffness of x-ray tube hanger, chest stand, cassette holder and table bucky also form its parts. Satisfactory performance of different types of movement, locks of the tube and smooth movement of collimator jaws and control panel switches should be ensured during the cause of the study.



X-Ray Machine



X-Ray Machine Control Panel

In the assessment of the physical x-ray operations the following are the necessary checks:-

(a) That the tube is perpendicular to the table surface.

(b) That regularity lamp of x-ray space is available.

(c) That regulating light of the bucky is available.

(d) That the X-ray and light space are coincident.

(e) That the padlock are operating

(f) That the axis of the x-ray is perpendicular to the film surface.

(g) That the grid grooves and the x-rays are in the same direction.

(h) That half value layer (at 80KVp) standard.

(i) That there is Record keeping.

2.7.2.2 Radiological Checks

Explanation of parameters and implications are given below.

(a) kVp accuracy:- The x-ray tube voltage (kVp) has a significant effect on the image contrast, the optical density and the patient dose. Therefore the kVp stated on the control panel should produce an x-ray beam quality with limit within ±5%. This test can be done with specialized cassette (such as Wisconsin or Ardan Test Cassette) using calibrated films) or with a digital meter. The digital meter is more accurate. kVp accuracy test is usually done by varying the applied voltage in steps , starting at 50 kVp up to the maximum available on the console.

Changes in the kilovolt peak may be caused by inconsistent line voltage supply, faulty high voltage cables or fault in the auto transformer or kVp selection circuitry. Accuracy of kVp should be done and reported at acceptance stage of the x-ray machine, and then annually when the machine is serviced.

(b) **Timer accuracy**: Exposure time directly affects the total quantity of radiation emitted from an x-ray tube, therefore an accurate exposure timer is critical for proper exposure of radiographs and control of patient dose. Tolerance limit for exposure time variability should be ±5% for t> 10ms and ±20% for t ≥ 10 ms. Traditional equipment for measuring timer accuracy such as the spinning top may work for single-phase or three phase machines, but modern equipment whose pulses are controlled by microprocessors. In these types of machine, the uses of voltage waveform in an oscilloscope or digital mAs meter are better options. Timer accuracy test should be performed on acceptance, then annually and after maintenance services.

(c). **mAs reciprocity and linearity**: The mA selector in an x-ray generator is used to regulate the x-ray tube filament temperature, which along with the exposure time, ultimately determines the quantity of x-rays in the x-ray beam.

Reciprocity implies that the generator produces the same radiation output for the same voltage and the different of mA x time combination (50mas x 1s = 100mA x 112s). Tolerance limit is ± 10%

Linearity means that increase in mAs should produce increase in exposure. The variance should not be more than ±10%. This measurement requires a dosimeter, but it can also be done by optical density method using a suitable combination of phantom and step wedges. Large variance in linearity can be an indication of mA selector, timer circuitry, or rectifier failure.

(d) Evaluation of focal spot: The area of the anode in the x-ray tube bombarded by projectile electrons is called the focal spot. There are two focal spots, the actual

focal spot which is from the perspective of the image receptor and the projected or apparent focal spot and the actual focal spot size. Focal spot size increases with machine age and use and with selected current.

Measurement of focal spot size can be done using a pinhole camera or more accurately a focal spot test tool. The test should be done on acceptance and then evaluated annually. The degree of blooming should not exceed ±50% of the nominal focal spot quoted by the manufacturers. The focal spot size of an x-ray tube is critically important in determining the detail of an X-ray image.

(e) **Collimator function**: The collimator is the beam restriction system responsible for regulating the size of patients anatomy exposed to radiation during examination. An increase in the beam size could result in larger scattered radiation and exposure of patients to higher or unnecessary or repeat exposures. Two factors to evaluate are the light-field and radiation field congruence and image receptor and radiation field alignment.

The light-field and radiation field congruency test measures how well the collimator regulates the radiation field size – that is the correspondence of the area illuminated by the positioning light and the area exposed on the radiograph. Misalignment can be caused by shift in the collimator mirrors or fault in the shutter mechanism. The congruence must be within 2%. The measurement can be done using the penny test or with a more effective collimator test tool. Perpendicularity of an X-ray beam to the film is important, but if the beam is not fixed properly the image may be distorted and becomes diffused. The accepted limit of beam misalignment should be within 0.5° i.e. if the images of the two steel balls

overlap the central ray, this ensures that the performance of the x-ray machine is satisfactory.

For measurement, if the x-ray field falls just within the image of the rectangular frame, then the alignment of the machine is good. But if the edge of the x-ray field falls on the first sport either H-cm on either side of the line (represented by dotted lines) it implies that, the edge of the x-ray field is misaligned by 1% of the distance between the x-ray sources and the table top.

The image receptor and radiation field alignment value must be determined for x-ray units equipped with positive beam limitation (PBL) or automatic collimation. These equipments have sensors in the bucky tray that detect the size of image receptor and automatically adjust the collimator shutters to match. Malfunction of this parameter can occur with age and use. This can be evaluated with the collimator test tool. Variance between x-ray field and image receptor size must be within ±3% of Source to Image Distance (SID). Facilities with PBL must have override switch.

Modern collimators have two knobs to allow control in X and Y dimensions. The indicated size of the collimator of X and Y dimensions and the actual size measured of the film must be within ±2% of SID.

Consequently, for any field misalignment greater than 3cm at 100cm source to image distance is not acceptable, because the misalignment is ≥ 3°. And this may result in blurred images or call for retakes.

If the X-ray beam is not perpendicular to the film, the images may be distorted and diffused using a grid.

$$For\ magnificatin = \frac{Measured\ diameter\ of\ the\ pattern}{actual\ diameter\ of\ the\ pattern}$$

$\Rightarrow M = \frac{D_2}{D_1}$ 2.8

where M = magnification

D_2 =measured diameter of the pattern

D_1 =actual diameter of the pattern.

Focal spot size = $\frac{Distance\ of\ blur-required\ along\ cathode-cathode\ side}{(m-1)}$ 2.9

Focal spot size = $\frac{N}{57.3} \times \frac{D}{M-1}$ (mm) 2.10

Where N = angle of bar pattern line

M = Magnification

D = is the diameter of zero contrast

v. **X-ray beam alignment**: Alignment of the x-ray beam to the bucky tray must be evaluated at acceptance, then annually. Parameters to be evaluated include; perpendicularity and central ray congruency. Loss of perpendicularity can be caused by rough handling of tube during examination or shifting of the machine. Tolerance is ±1. Loss of central ray congruence can cause clipping of important anatomy in the resultant image of grid cut off. Tolerance is ±1% of SID. This measure is done with a beam alignment test tool or with a washer or coil method Nzotta (2007).

Most modern equipment have SID indicators, SID influences patient dose and must be accurately determined to a tolerance of ±2%. A simple tape can be used to measure this parameter. The check should be done on acceptance, then annually.

vi. **X-ray output**: The specific radiation (mSv or μCkg^{-1}) mAs value for a machine should be constant with time and similar for different generations and tubes within

an establishment if streamlining of the technique is to be adopted. Some licensing organizations require that this value be posted at the start of the use of the machine and future values should not vary beyond ±10%.

vii. **HVL of the x-ray beam**: Filtration is necessary to remove low energy photons that would unnecessarily contribute to patient dose. A patient skin dose can be increased by as much as 90% if these photons are not removed. This test should be done on acceptance, then annually or after service. Half-value layer measurement is the best method of determining if the filtration is adequate or not. Inherent filtration cannot be accurately determined because the filament evaporation that takes place in the tube add new layer of tungsten inside the tube window. The HVL at 80kVp should be ≥ 2mmAl. Acceptable values of HVL are given by the regulatory bodies or given in the manufacture's manual. To test the adequacy of filtration, the ratio of exposure reading with and without 2.3mmAl is found with tolerance value between 0.5 and 0.75. Values higher than 0.75 may be an indication of tube failure due to excessive tungsten deposit.

The method used to specify the quality of the x-ray beam is by determining the half-valued layer (HVL) of the x-ray beam. For a given kVp a measurement of the HVL gives information on the total filtration in the x-ray beam. That is to say, too little results is unnecessary radiation exposure to the patient. Similarly, too high HVL reduces the image contrast and the diagnostic information. HVL is normally measured at specific kVp (80) and maintain at all times. The mA and time (sec) for measurement were chosen such that a full scale reading is obtained on the ion-chamber without aluminum attenuation in the beam. To ensure consistency, three readings should be measured with the same mA and sec. Additional measurement should be taken with the same mA and time, but with increasing

thickness of aluminum attenuating sheets positioned between the x-ray source and the ion chamber. This procedure is repeated until the ion chamber reading is reduced to half of its average value.

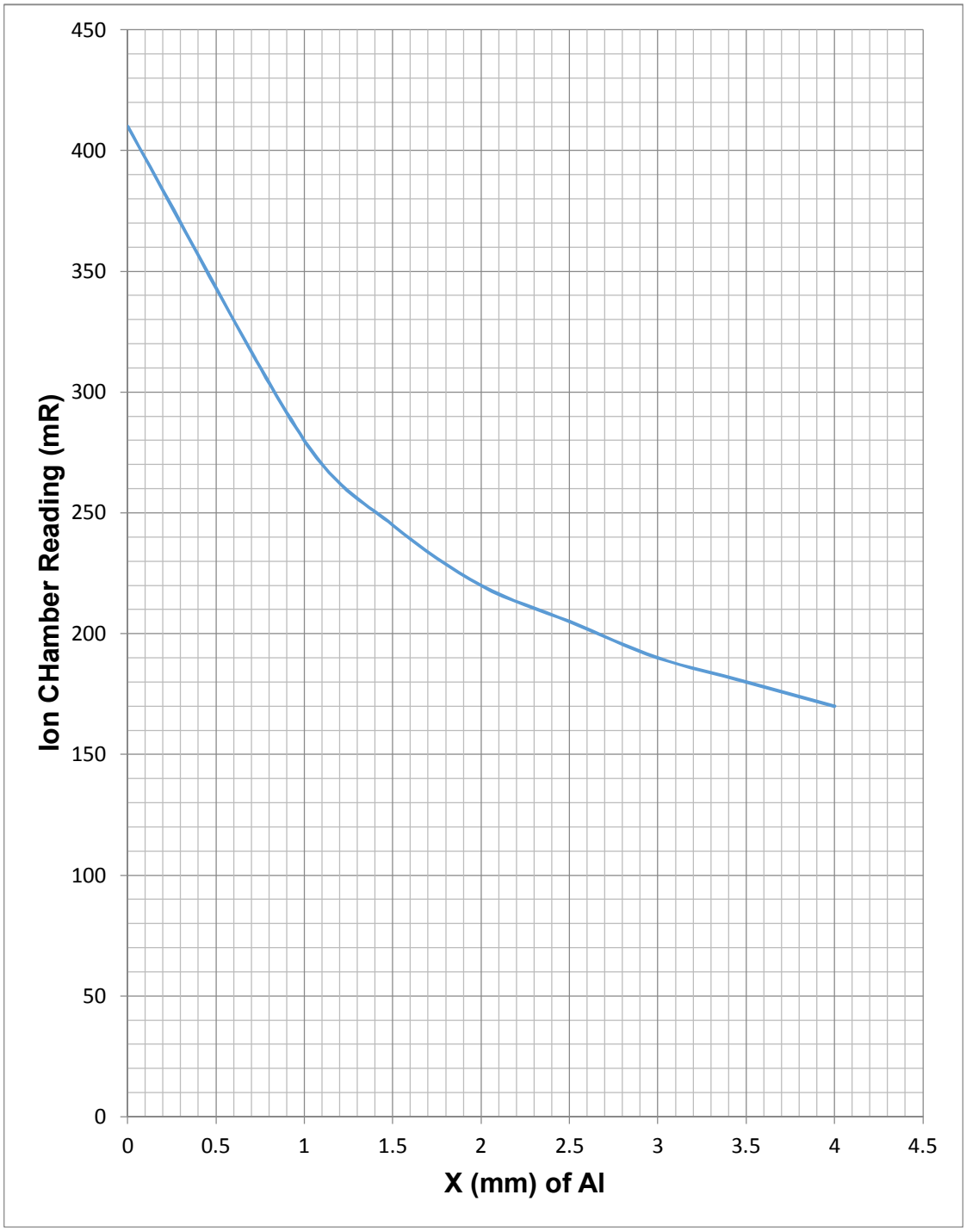


Figure 2.3: *Ion Chamber Reading (mR) Vs All Thickness (mm)*

HVL value of the X-ray beam is used to judge the adequacy of filtration and this reflects the penetration power of the beam. Too low filters will allow low energy x-ray to fall on the patient which increases the patient-dose without any enhancement of diagnostic information.

viii. **Film-screen contact with cassettes**: Most images recorded using conventional analog radiography is made with film-screen combination. The screen provides fluorescence that is used to expose the films. Between 95% and 98% of the images are produced by optical luminescence from the screens, while only a little fraction is produced by x-ray interaction.

ix. **Grid alignment:-** Grids are the most common device for controlling scattered radiation (assuming proper collimation of the appropriate field size) improper use of grid can cause grid cut off (resulting in an underexposed radiograph) or grid artifact (e.g. grid lines and other patterns). Grid imperfection can also occur during manufacturing or due to mishandling. Therefore, grid alignment measure should be made at acceptance and then at regular intervals. Grids that are misaligned attenuate primary x-ray causing loss of image quality and higher patient dosage. This type of test can only be done with grid alignment tool and conformance with manufacturer's specification must be confirmed.

If the grid is properly aligned, the middle hole will display the greatest density with the surrounding holes displaying symmetrically decreasing density then the system has a max grid misalignment of ½ inch.

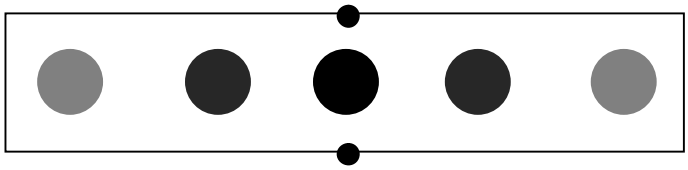


Figure VI *Showing Centred grid*

Fig. VI shows that the centriole has the maximum optical density and the surrounding holes show symmetrical decrease in density. If the middle hole, does not show the greatest density or the surroundings holes do not show a symmetrical decrease as in Fig. VI above then there is grid misalignment.

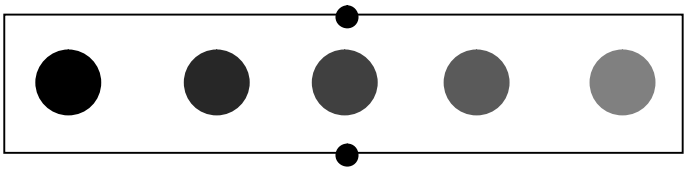


Figure 2.5 Un-centered grid showing max density to the left of center.

x. **Consistence of mA stations:** The law of reciprocity states that the same amount of radiation should be created at any mill ampere – second (mAs) value regardless of mA/time combination used. Reciprocity failure can occur at small or very large exposures. This consistency values should be tested and its limits stated to 10% maximum variation for acceptability.

2.7.3 Assessment of the Exposure Parameters

Assessment of the Exposure Parameters will be carried out by checking the following:-

(a) kVp accuracy, reproducibility and consistency.

(b) Exposure time accuracy and reproducibility.

(c) Output linearity coefficient and reproducibility

The techniques used in monitoring the facilities in the department would be evaluated. The parameters involved or needed to be monitored would be verified. The result

obtained would be compared with the standard quality control /quality assurance minimum standard as stated in IAEA (1996).

2.8 Safety Culture

By definition, safety culture is that assembly of characteristics and attitude in organizations and individuals which establishes that, as an overriding priority. Nuclear safety issues receive the attention warranted by their significance Rahani (1995).

All organizations need direction and the management style of those in charge directly affects the attitudes, behavior, motivations and intentions of those who have to carry out the work. So it is management prime task to gain the confidence and trust of the worker and to engender a sense of ownership in the organization.

All safety considerations which are applied to conventional and personal safety are affected by common points of belief, attitudes, behavior and cultural differences which are closely linked to a shared system of values and standard. The significance of nuclear safety issues vary among organizations and it reflect their particular needs. Therefore there is need to choose which issue are to be addressed as a priority taking into consideration the resources available.

2.9 REVIEW OF PREVIOUS WORK.

A survey of the number and causes of spoiled x-ray films which was carried out under the aegis of the radiation protection committee of BIR (British Institute of Radiology) revealed that exposure fault at all cases were the major reasons for retakes particularly in films taken with portable radiographic equipment and also mal positioning was shown to be the major causes of about 25% retakes. (Vasileva J. 2002).

The US Bureau of radiological health cited in on European Commission's study the impact of the choice of image receptor on the exposure variation. Their statistical analysis of the posterior/anterior(P/A)Chest projection using parameter such as kVp, HVL, image receptor, grid, etc. Found that these factors caused about 50% of the exposure to deviate from the machine settings. They also reported that prevalence of such machine malfunctioning can be greatly reduced by effective quality assurance program.(European commission,2001).

A Study of a number of general radiography facilities by the Daleware USA (DU) as cited in IAEA TECDOC 1423 of 2004 revealed that, an average of 9% of the radiographs taken had to be repeated. An analysis of the reasons for rejections and hence repeats led to the conclusion that poor equipment performance made a significant contribution to the prevalence of the poor image quality.

An early indication of the existence of radiology facilities producing poor quality image was revealed by medical surveillance program conducted in the United States of America by the National Institute for Occupational Safety and Health in association with the Department of Labor's pneumoconiosis compensation program found that despite the pre-screening and reader, about 44% of the facilities that participated in the first round of examination had from 10%-40% of their submitted radiographs rejected. The reasons being of inadequate quality for diagnosis of pneumoconiosis. Some of the reasons for the inadequacy were related to poor equipment performance. (Sniurevicente M and Alience D,2005).

In Optimization of Radiation Protection checks on diagnostic radiology equipment in some Nigerian hospitals it was found that equipment malfunctioning and human factor contribute to repeat or retakes of radiographs. It is also found that X-ray equipment over fifteen years

should no longer be used for routine procedure considering their high kilo voltage and exposure time variance with set values. This if done will help in reducing the incidence of over exposure to the staff, patient and general public. (Nzotta, 2007).

In the study on Diagnostic X-ray facilities as per quality control performance in Tanzania reported that the status on the X-ray machine in Tanzania, four QC test were performed on a total of 196 units, result shows that 59% failed kVp test, 57% failed Time Accuracy test60% failed beam alignment, 53% of the units are defective and 34% were out of order. Yesaya et al (2006).

Study on the quality assurance of conventional X-ray machines using non-inversive kV meter, their result shows that the beam alignment ranges from 0.3 to 0.7 centimeter, HVL exceeded the minimum value above 2.3 mmAl at standard and acceptable limit (T. M Taha 2010).

Study on the determination of HVL of X-ray equipment using computed radiography imaging plates the HVL in their work ranges from 1.8-2.5mmAl. (Ariga et al 2012).

CHAPTER THREE

3.0 MATERIALS AND METHODOLOGY

3.1 Introduction

The research was carried out on five (5) hospitals in Zaria metropolis in all the hospitals daily monitoring and developer temperature and processing cycle time were performed. For the x-ray room of each of the hospitals, machine specific data such as model, work form, filtration, film screen combination and output were checked and recorded. This work mainly focused on mechanical and radiological checks on radiological equipment. The hospitals used for this work were:

i. Ahmadu Bello University Teaching Hospital, Shika, Zaria. Zaria

ii. Saye Leprosy Hospital, Zaria

iii. Jalva Radiodiagnostic Centre, Zaria

iv. Pal Hospital, Zaria

v. Tukur Tukur Medical Center Zaria

The hospitals were chosen based on patient patronage, cooperation and availability.

3.2 Materials

Quality Control Kit

Based on the systematic collection of data on the radiation protection aspect of radiological practices and the review of the data possible ways of reducing unwanted exposure and doses were identified. The QC checks were based on the following

(i). Suitability of the equipment and accessories.

(ii) Adequacy of the equipment from periodic maintenance records.

(iii) Conformity of the radiation protection practices to recommended standards.

In this research, the following materials were used for measurement

The materials used in the kit includes:

(i). RMI multi-function meter model 240. This equipment is based on the differential absorption of X-ray through filters used for ionizing chambers for radiographic assessment e.g. kVp (average peak), effective peak kVp and duration of exposure. It operates on four pencil battery cell of 1.5v

(ii). The HVL Attenuator set Model 115A, in conjunction with a dosimeter such as Gammex DR1897 ion chamber, is designed to be used for determining the HVL of an X-ray machine. The aluminum HVL set consist of nine aluminum plates 10cm square of thicknesses; 2mm(1),1mm(2),0.5mm(2),0.2mm(1),and 0.1mm(3).

(iii). The Grid Alignment Test Tool RMI 144, which is used to test the alignment of the radiographic grid with respect to the central ray of the X-ray tube. It is a plastic covered lead blocker containing five (5) large holes with their centers spaced one inch apart. It is excellent for detecting lateral decentering or tilting of the grid.

(iv). Collimator and Beam Alignment Test Tool Model161B and 162A.The model 162A Beam Alignment Test Tool is a plastic cylinder of 12.25cm tall and 1.6mm diameter steel ball at each end. The model 161B collimator Test Tool is a flat brass plate with a rectangular outline javomg etched on its surface.

(v). Film –Screen Contact Test Tool RMI142D and RMI143D were used to identify screens with poor contact or artifacts.

(vi). Focal Spot Test Tool Model 112B was used to detect gradual deterioration in the focal spot before clinical images are affected.

3.3 Methodology

The highest contributing factor of the critical sources of radiation to the public is the medical exposure and this is also of great concern to the hospital workers involved in the exposure. There are parameters used in evaluating the importance of quality assurance in a diagnostic radiology department, these parameters ensures the effectiveness of the quality assurance practices. The parameters are

(j) Human and organizational parameters

(k) Equipment parameters.

Based on this, an empirical and evaluating study was carried out on the selected hospitals.

The following steps were considered in carrying out this research.

1. Mapping out approaches.
2. Data collection
3. Data presentation and analysis
4. Interpretation of results.

In the course of this research, the preliminary steps were explained to staff (whose assistance will be required), the nature and purpose of the study was also explained to them. An assurance was given to the Chief Radiographers and Assistant Chiefs of the Departments, that the findings of the research will not be released to any outside for disciplinary action but would only be used for academic and constructive reformations.

3.3.1 Quality Control measurement and test

Some of the measurements and test performed on the radiological equipment and practices includes, locking facility, tube orientation, localizing light, accuracy of focus to table top, couch movement, generator etc. to determine the adequacy and the radiation protection practices of the chosen hospitals.

Room dimensions were taken to ensure NNRA requirement followed by mechanical checks on the equipment before running the test. According to NNRA requirement, an x-ray room should be at least $16m^2$.

3.3.2 The Radiological Test

i. Peak Tube Voltage (kVp)

Multifunctional meter (RMI) model 240 was used to measure the kVp. The meter has the capability of presenting kVp, exposure time from a single exposure.

Measurement: The equipment (RMI) model 240 was placed on the X-ray couch and X-ray beam was incidental on it such that the central beam passes through it. The meter automatically measures and displayed the measured value of the peak tube voltage and a liquid crystal display screen (LCD). Based on the international standard unit, the tolerance limit of accuracy is ± 5% while the reproducibility limit is ±2% (knowing that kVp is a measure of the quality of radiation produced.

kVp was set at 60,70, 80, 90, 100 and in which three (3) readings were taken for each.

ii. Exposure Time

The multifunctional meter RMI model 240 was used to measure the time of exposure and check on the accuracy of exposure time in X-ray unit the time in set at 100, 200, 300, 400, 500ms and three (3) readings were taken for each. The International Standard lines of accuracy is ±10% and linearity of exposure time should not be less than 70% for $t > 10ms$ is ±5% and 20% for $t \geq 10ms$.

(iii) Film-Screen Contact:

The multifunctional meter RMI model 142D and 143D test tool were used to assess any blurring or dark patches in the image produced. kVp was set at 50, 70 and mAs at 5 and 8 respectively, three (3) readings were taken for each. Film were read directly and poor contact easily identified.

iv. Half-Value Layer (HVL)

Aluminum sheet of different thickness were provided to determined total filtration in the X-ray beam. Original value of ion chamber for each hospital was obtained kVp was set at 80 and maintained at 10mAs. The HVL at 80 kVp should be ≥2mmAL. The standard tolerance value should be 0.5 and 0.75. If the HVL value, are less than 0.5 or greater than 0.75, it indicates that there is tube failure which may be due to excessive tungsten deposit.

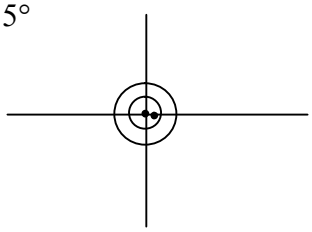
v. Collimator/beam Alignment

The RMI model 16/3 tool designed for collimator test tool was used in conjunction with RMI model 162A test tool designed for beam alignment test.

Collimator test tool (model 161B) is a plastic cylinder 12.25cm and 6mm diameter steel ball at each end. While the beam alignment test tool model (162A) is a flat brass plate with a rectangular outline.

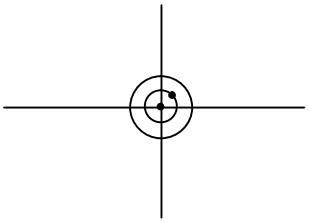
Measurement: The table was leveled with the help of spirit level. A loaded cassette was placed on the table. The collimator test tool was placed on the cassette and the beam alignment tool was placed at the centre of the collimator test tool. X-ray tube was directed over the collimator test tool at a distance of 100cm from the film cassette and the optical field was collimated at the marked rectangle. The film was exposed to about 55kVp and 8mAs and then developed.

If the two steel balls overlap, it meant that the central ray was perpendicular to range and the perpendicular taken as 0.5°



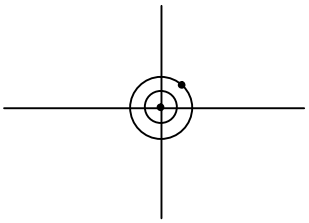
the small difference ·· represents the steel balls.

But if the steel ball the image of the top ball (larger) intercept the first circle the beam alignment is 1.5° away from perpendicularity. And, this is within range or limit allowed.



Perpendicularity is 1.5° away

Similarly if the image of the large top ball intercept the second circle, it shows that the beam is 3° away from perpendicularity. It is unacceptable because the image will show different thing than what is required.

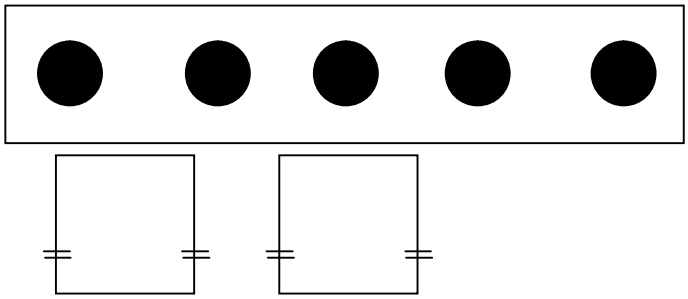


3° away from family

This implies that the international standard best acceptable degree of perpendicularity which physicists should endeavour to achieve is 0.5° at least to ensure satisfactory performance of the X-ray machine.

vi. Grid Alignment

RMI model 144 was used for the alignment of the radiographic grid with respect to the central ray of the X-ray tube. Grid alignment test tool was a plastic covered lead blocker containing five (5) holes with their centres spaced an inch apart. Several smaller holes provide marking exposures on the film to indicate the tool orientation.

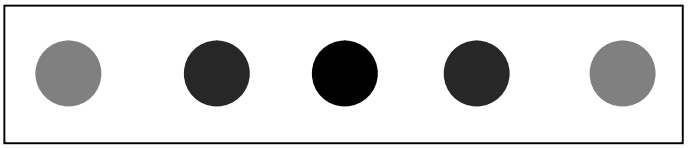


Grid alignment

Measurement:

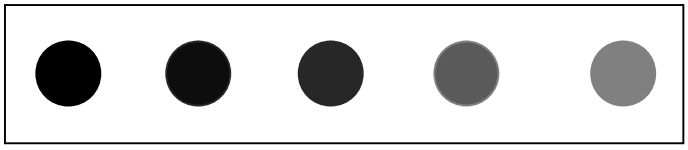
A cassette of (20 x 25cm) was position on a tray, such that long dimension of the cassette was perpendicular to the long dimension of the table. X-ray tube was centered with respect to the image receptor both longitudinally and transversely. The height of the tube was adjusted to a proper source to image distance (SID). RMI Grid Alignment test tool was placed on the table so that the three marking holes face the front of the table. Only one large hole was exposed at a time using the small lead blockers to cover the four unexposed holes. The middle hole was exposed at 60kVp, 4mAs. The procedure was repeated until all the five (5) holes, were exposed and the film was developed.

For acceptable standard, the middle hole will display the greatest density, this signify proper grid alignment i.e.



Centred grid

If the grid is not properly aligned the middle hole will not display greatest density



Uncentered grid

vii. Focal Spot Test Tool

The focal spot test model 112B consists of a metal target with 12 bar pattern groups of different sizes. Each group has six slots, three horizontal and three vertical. The sizes and spacing of the slots ranges from 0.84 line pairs/mm to 5.66 line pairs/mm (lp/mm), with each group being 16% smaller than the last pair. The focal spot test tool was to detect gradual deterioration in the focal spot before clinical images are affected. It is critically important in determining the detail of an x-ray image.

Measurement:- The distance between the pattern and the tube was set at 61cm film to focal distance (FFd), 80kVp and 10mAs. An X-ray film without an intensifying screen e.g. Cardboard cassette was used. Exposure was made and the film was developed and scanned.

Some of the measurements and tests performed on the radiological equipment and practices were to determine their adequacy and to find out the radiation protection practices of the chosen hospital.

3.3.3 Data Collection

In the course of this study, preliminary steps were explained to staff, the nature and purpose of the study was also explained to those whose assistance would be required some of the measurement and test performed on the radiological equipments and practice determines the adequacy and radiation quality control of the selected hospitals. Thus, the effects of radiological test on the quality of the radiology department were measured and the results were used to substantiate or reject the results of the QC of each hospital

CHAPTER FOUR

4.0 RESULTS

4.1 Mechanical Check on X-Ray Machine

From our findings it was obvious that some of the machine parameters were unacceptable from the acceptable operational point of view, considering the hospital utilities, we tried to eliminate the problems. X-ray and light space at the different hospitals were not the same which leads to the needs of repeated exposure which could consequently increased patient absorbed dose.

Table 4.1: Results of Performed Physical Operation of the X-Ray Equipment of the Selected Hospitals

Parameter	Hospital Findings				
	A	**B**	**C**	**D**	**E**
1. The tube is perpendicular to the table surface	✓	×	✓	×	✓
2. Regulating lamp of X-Ray	✓	×	✓	×	✓
3. X-ray and light space are coincident	✓	×	×	×	✓
4. The padlock are operating	✓	✓	✓	✓	✓
5. The axis of the X-ray is perpendicular to the film surface	✓	×	✓	×	✓
6. The grid grooves and the X-ray are in the same direction.	✓	×	✓	×	✓
7. Movement of diaphragm	✓	✓	✓	✓	✓
8. Localising light	✓	✓	✓	✓	✓
9. Accuracy of focus to table top	✓	-	✓	-	✓
10. Room Dimension	✓	×		×	×

Where:- × = bad
✓ = good

4.2 Room Dimensions

General radiographic rooms should according to NNRA recommendations and requirement approximately be $16m^2$. This is to provide for sufficient space and a shielded protective cubicle. The others are that the access doors should be of the sliding type giving better radiation protection, with a clearing of 1.5m as recommended by NNRA, 60 (2005). Based on standard, the overlap should be 100mm each side; the doors should be lined with lead sheet of 2mm thickness. Also the walls should be 230 mm Kiln baked solid clay brick or 2mm lead sheet sandwiched between partitioning. Walls should be protected up to a height of 2.2m.

The X-ray rooms should preferably be sited on the ground floor of a building. If the x-ray room is above ground level, the solid concrete slab of density $2.35g/cm^3$ of 150mm thickness should be in place.

Adherence to the standard will provide a better radiation protection and also reduce effect of radiation scattering via secondary radiations and unnecessary exposure.

Table 4.2 Room Dimension of the Selected Hospitals

Hospital	Room Dimension	Protective Cubicle	Shielding
A	$16m^2$	Available	No lead lining
B	$12/14\ m^2$	No Space	No lead lining
C	$14/14m^2$	Available	Available
D	$12/10m^2$	No Space	Iron sheet lead lining
E	$13/16m^2$	Available	Available

The expected standard room dimension is approximately 16 m^2. X-ray room of hospital D is situated within the hospital ward which may increase patient background radiation.

4.3 Radiological Test

The x-ray tube voltage has a significant effect on the image contrast, the optical density and the patient dose. It is therefore expected that the kVp stated on the control panel should produce an X-ray beam of the stated voltage. The variation between the kVp and X-ray beam quality must be ±5% to be accepted.

4.3.1 Peak tube Voltage (kVp):

This test measured the kilovoltage across the x-ray tube, since kVp affects the intensity of the x-ray output as well as contrasts of the image. The test ascertains if kVp selection of the control panel produces the same amount of voltage applied cross the tube. RMI multifunction meter model 240 was used for the test. This meter works based on the differential absorption of X-ray through filters and it uses four balance ionization chamber to assess radiographic characteristics Rahani (1995).

Changes in the Kilovolts Peak may be calculated by

$$Variation\ of\ voltage = \frac{V_{max} - V_{min}}{V_{max}} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 4.1$$

Where V_{max} = Maximum Voltage

V_{min} = Minimum voltage

Whereas the Coefficient of Variance can be calculated using

$$\text{Coefficient of Variance} = = \frac{Standard\ deviation}{Mean} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 4.2$$

The tolerant limit of the kVp is within ± 10% whereas the accepted tolerance limit of coefficient of variance should be ± 5%.

Table 4.3 kVp Output Consistence for the selected hospitals.

KVp	Hospital				
	A	**B**	**C**	**D**	**E**
60	**62.8**	**90.9**	**60.9**	**-**	**61.9**
70	**72.8**	**90.7**	**62.9**	**-**	**61.3**
80	**88.5**	**91.1**	**70.7**	**98.6**	**73.8**
90	**93.5**	**91.1**	**80.5**	**-**	**99.5**
100	**105.1**	**91.1**	**88.0**		**101.5**

The kVp output at hospital A is within the range but at 80kVp the exposure was high which signified over exposure to patient .For hospital B the kVp output is the same at both low and higher values. This implies that, there is over exposure at low kVp and under exposure at higher kVp. From all indication the kV set is not setting the correct kVp, that is why the same values are obtained. For hospital C, kVp output is within range but at higher kVp the values shows under exposure. Hospital D has fixed kVp at 80 kVp, because the settings at the control panel cannot be altered. This implies that exposures at 60, 70, 90, 100 kVp are not possible. It shows that exposure at such hospital is dangerous the percentage of under exposure and over exposure cannot be estimated. Similarly, at hospital E, there is linear kVp output consistency from 60, 80 and 100 kVp, while there is under exposure at 60 and over exposure at 90kVps respectively. The changes in the kilovolt could be due to inconsistent line voltage supply, faulty high voltage cables or fault in the autotransformer kVp selection circuitry.

Table 4.4 Reproducibility of kVp of the Selected Hospitals.

Settings	Hospitals				
kVp at 70kV	**A**	**B**	**C**	**D**	**E**
	0.02	**0.13**	**0.03**		**0.07**

Reproducibility =kVpmax-kVpmin/kVpmax +kVpmin

The reproducibility of hospital A, is 0.02 representing 2% while the standard value of tolerance limit is 5%. In hospital B the percentage reproducibility is 13% signifying high expending radiation exposure on patient. Also, hospital C has 3% and, hospital E has 7% respectively.

4.3.3 Timer Accuracy – (mA)

Exposure time directly affects the total quantity of radiation emitted from an X-ray tube, therefore an accurate exposure timer is critical for proper exposure of radiographs and control of patient dose.

Time calibration needs variation of resistance (potentiometer) to change the charging (or discharging) time of the resistor-capacity circuit. It is independent of variation of the potential of the input power supply which makes it more stable once it is calibrated by adjusting the potentiometer. Modern digital times use a source fixed, high frequency, pulses and a counting circuit holds the switch closed for the period required to account a predetermined number of pulses. The acceptable tolerance limit for exposure time variability should be within ±50% for t > 10ms and ±20% for t ≥ 10ms.

The checks for exposure time of x-ray unit. RMI multi-function meter model 240 was used and the following results were obtained on average exposures.

The coefficient of linearity of the exposure time was calculated using the formular Rehani (1995).

$$Coefficient\ of\ Variance = \frac{\left(\frac{mR}{mAs}\right)_{max} - \left(\frac{mR}{mAs}\right)_{min}}{\left(\frac{mR}{mAs}\right)_{max} + \left(\frac{mR}{nAs}\right)_{min}} \quad \ldots\ldots\ldots\

Table 4.5 The accuracy of exposure time of the selected Hospital
At fixed kVp (70) and FFD 100cm.

	Hospitals				
	A	**B**	**C**	**D**	**E**
Time accuracy %	**0.82**	**X**	**0.83**	**X**	**X**
Implication of Exposure Time					

Table 4.5 implies that, the exposure was of hospital A and C have good reproducibility and accuracy. While the hospital that does not have exposure time on their control panel, risks the life of patient to over exposure of radiation. Accurate exposure time controls patients dose.

4.3.4 Check for Film –Screen Contact

Thus, to assess any blurring or dark patches in the image produced in radiographic unit, RMI multifunction meter model 142D and 143D film-screen contact test tool was used. Blurring of image occurs as a result of poor contact between film and the screen. Poor contact give rise to diffusion of light emitted by intensifying screen, so it results in blur or dark images.

These test tools constitute mesh conflicts of brass wires of diameter 0.5mm and rest spacing of about 33m. The wire mesh is embedded in 33m thick perpexsheet, it is large enough to cover cassette of all sizes about (36cm × 44cm) dimension within the optical density of 1.0–2.0.

Table 4.6 Film Screen Contact (image description) at various set of kVp and mAs of 50, 70 ≤ 3.5, 5, 8mA.

Settings		Hospital and Image Description				
kVp,	**mAs**	**A**	**B**	**C**	**D**	**E**
50	**3.5**	**Dark**	**Dark**	**Blurred**		**Dark**
50	5	**Dark**	**Dark**	**Blurred**		**Fairly clear**
50	8	**Clear**	**Blurred**	**Clear**		**Clear**
70	3.5	**Blurred**	**Blurred**	**Fairly clear**		**Clear**
70	5	**Cleared**	**Fairly clear**	**Clear**		**Clear**
70	8	**Dark**	**Blurred**	**Bright**		**Bright**

Implication

Blurred/Dark images implies that the radiodiagnostic information required cannot be assessed which requires retakes or rejects of the film, these laterally exposures the patients more to radiation.

4.3.5 Check for HVL

Filtration is necessary to remove low energy photons that would unnecessary contribute to patient dose. Patient skin dose can be increased by as much as 90%, if these photons are not removed. HVL is used to estimate the thickness of shielding required to reduce the radiation intensity to permissible dose rates. The fractional reduction in intensity one obtains with various values of HVL are as follows (fig. 4.8).

Table 4.7 Original Value of Ion Chamber of the Selected Hospitals

Hospitals	KVp	Meter Reading					
		mAs	1	2	3	Average	Average/2
A	80	10	0.066	0.064	0.064	0.064	0.032
B	80	10	0.239	0.234	0.241	0.238	0.119
C	80	10	0.006	0.006	0.015	0.009	0.0045
D	80	10	0.038	0.020	0.038	0.032	0.016
E	80	10	0.047	0.050	0.048	0.048	0.024

Table 4.8 Result of Half Value Layer of the Selected Hospitals.

HVL			,Hospitals							
	A		B		C		D		E	
Al_{mm}	Ave	mR/min	Ave	mR/min	Ave	mR/min	Ave	mR/min	Ave	mR/min
0.1	0.062	62	0.232	232	0.011	11	-	-	-	-
0.2	0.060	60	-	-	0.056	5.6	0.027	267	0.045	45
0.3	0.059	59	0.189	189	0.0067	6.7	-	-	-	-
0.5	0.056	56	0.212	212	0.0057	5.7	-	-	-	-
0.7	-	-	-	-	-	-	-	-	0.039	39
1.0	0.051	51	0.175	175	0.0043	4.3	-	-	-	-
1.2	-	-	-	-	-	-	0.035	35	0.035	35
1.5	-	-	0.163	163	-	-	-	-	-	-
2.0	0.036	36	-	-	-	-	-	-	-	-
2.2	-	-	0.149	149	-	-	0.046	46	0.029	29
2.5	-	-	0.138	138	-	-	-	-	0.027	27
3.0	0.032	32	-	-	-	-	-	-	0.025	25
3.2	-	-	-	-	-	-	0.028	28	0.024	24
3.5	-	-	-	-	-	-	-	-		
4.0	-	-	0.121	121	-	-	-	-		
5.5							0.03	30		

HVL is dependent on the energy of radiation and the type of shielding material.

Implication of Half-Value Layer

HVL is that thickness of absorbing material that reduces the intensity of X-ray beam to one half it's original value. The minimum HVL requirement for X-ray units.

kVp	Minimum HVL (mm of Al)	Reading of HVL obtained in the Hospitals				
		A	**B**	**C**	**D**	**E**
80	2.3	3.0	4.0	1.0	5.5	3.2
90	2.5					
100	2.7					
110	3.0					
120	3.2					
130	3.5					

The results above implies that exposure made at 80kVp and above requires thicker shielding to reduce the radiations photons.

This is normally caused by X-ray tine age and frequent usage. With constant use, the targets surface pits can become rough which increases filtration of the tube. Thus HVL should be measured at least annually or after replacement of the X-ray tube assembly. Thus higher energy radiation should not be exposed or is not adviceable.

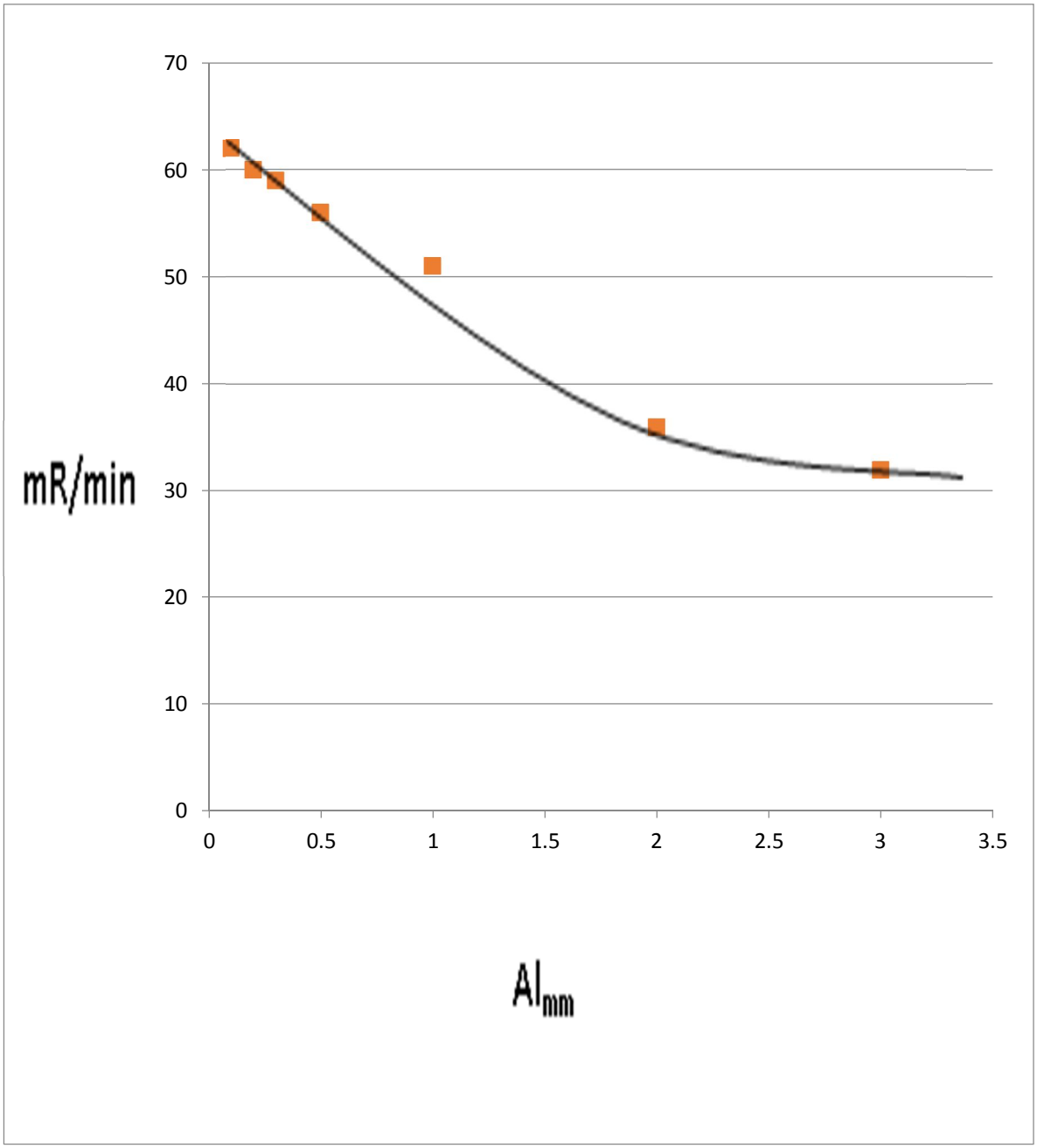


Fig. 4.1 Showing graph of HVL of hospital A

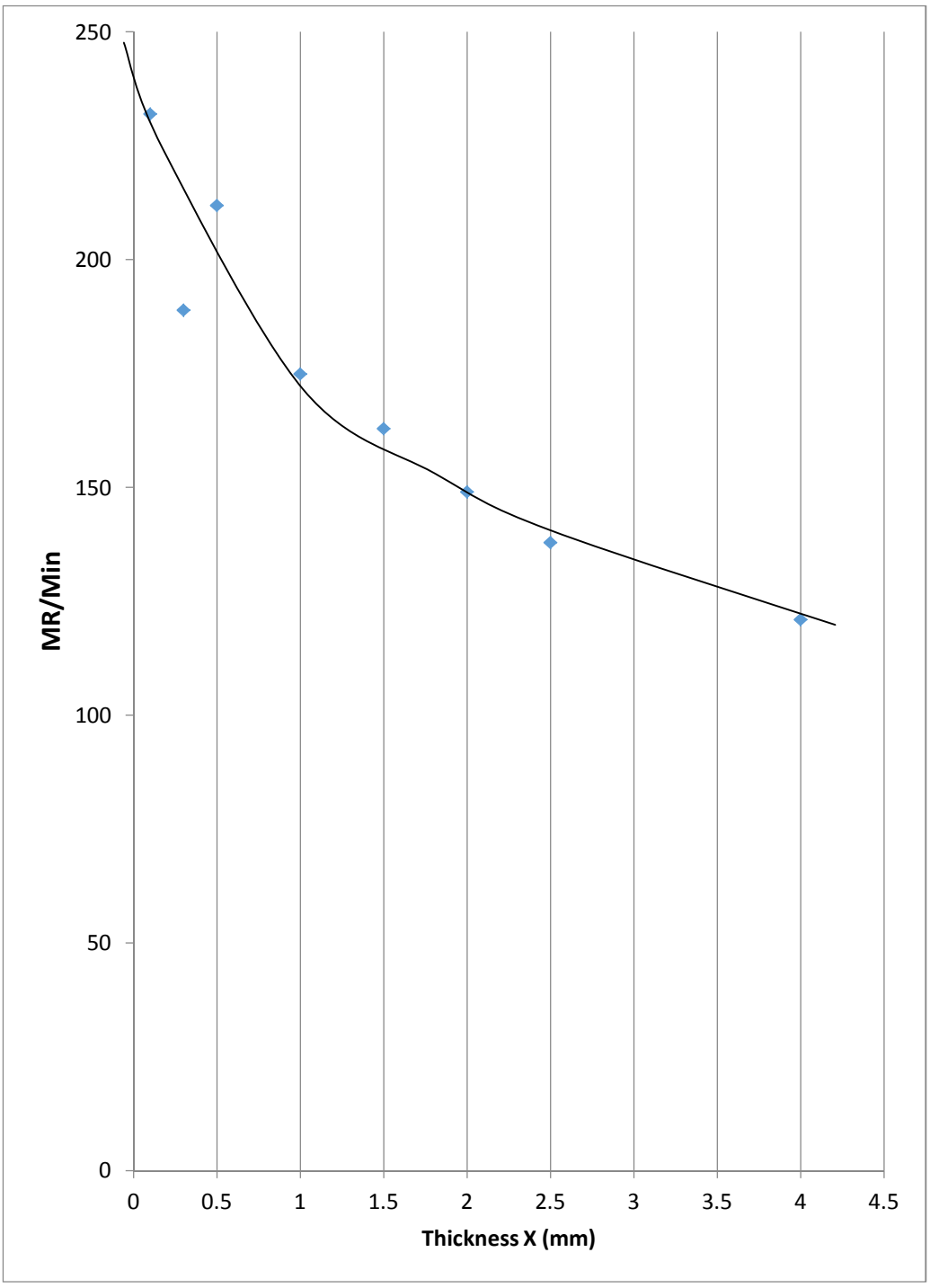


Fig 4.2 showing HVL of hospital B

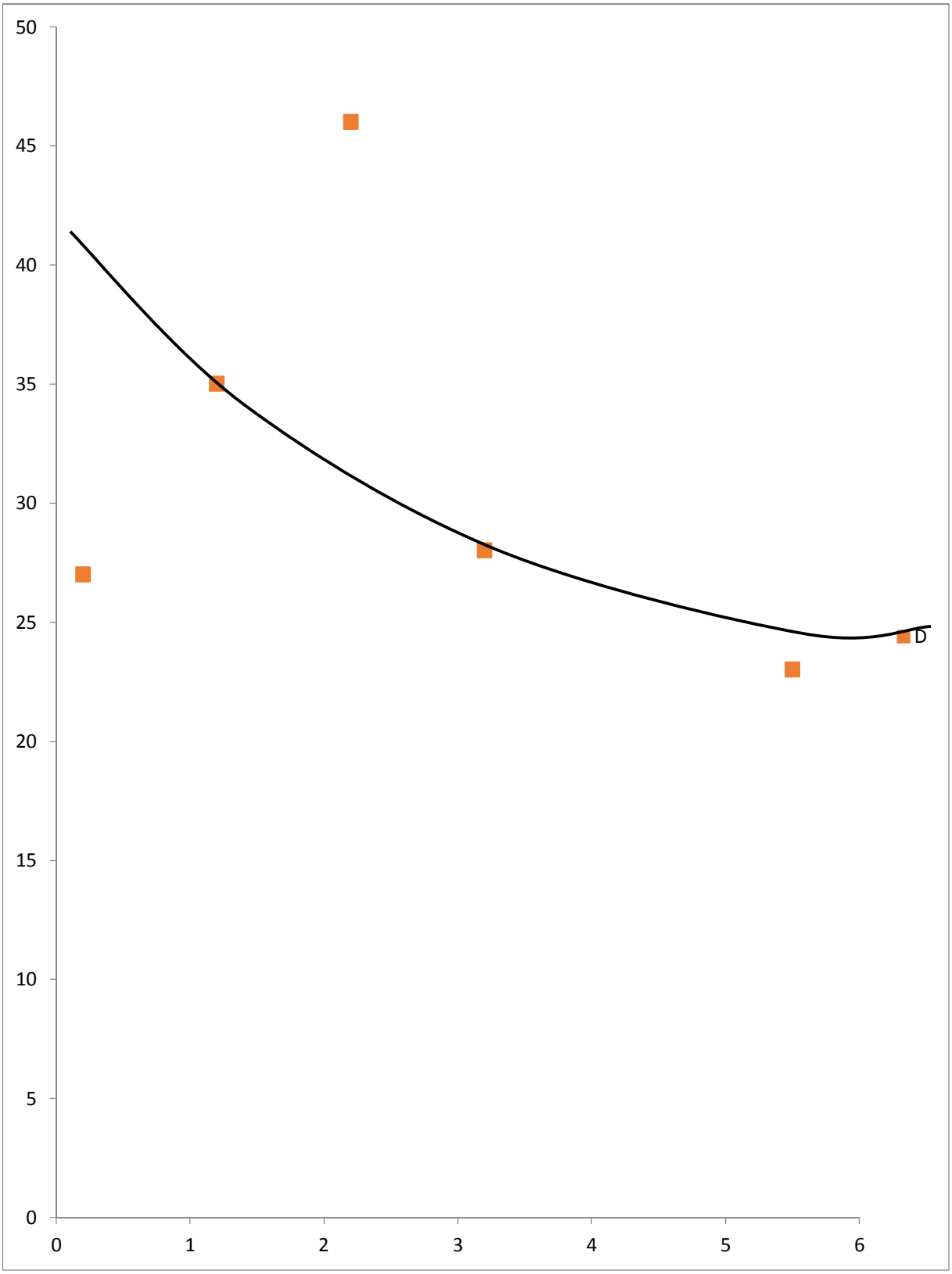


Fig. 4.2 Showing graph of HVL of hospital D

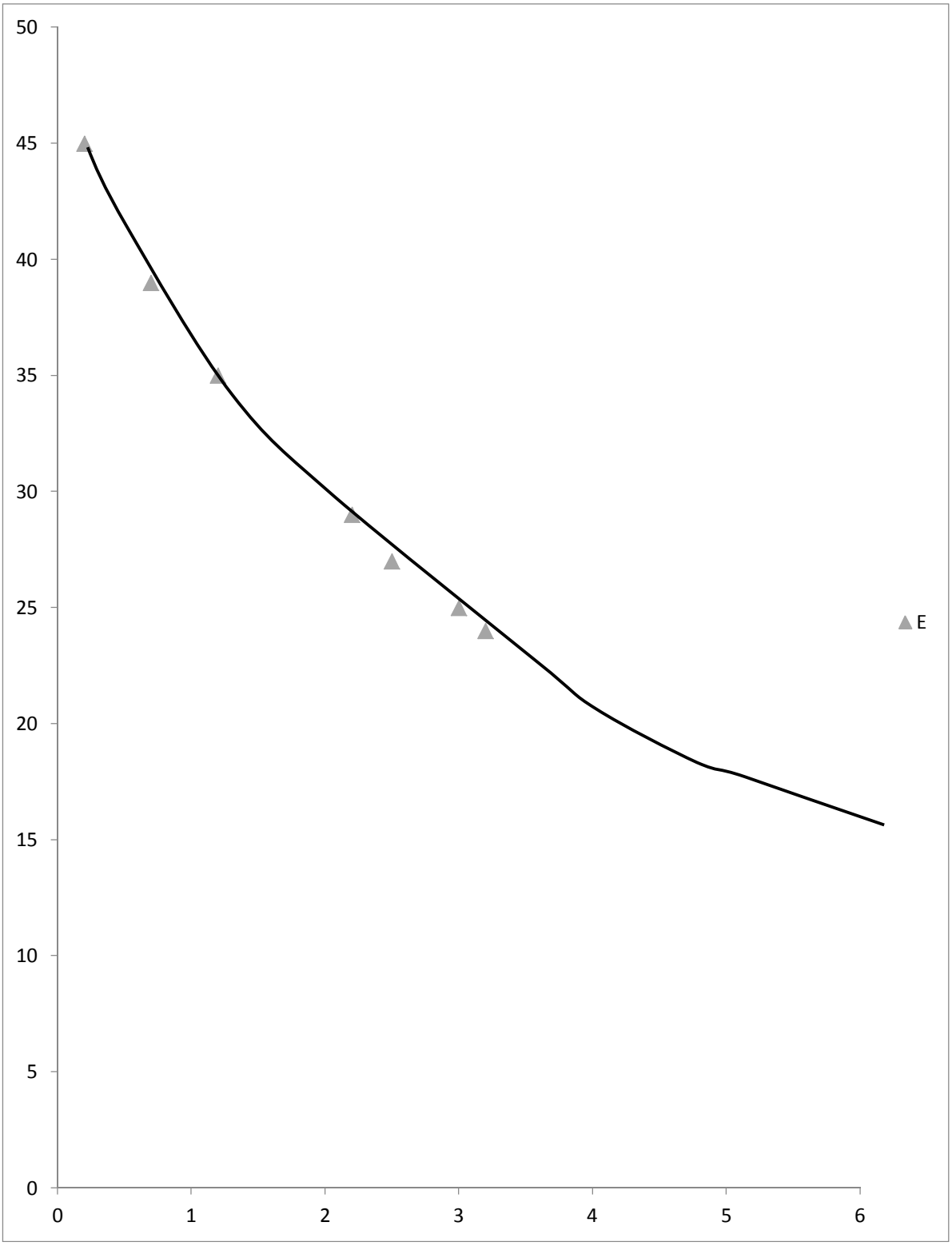


Fig. 4.3 Showing graph of HVL of hospital E

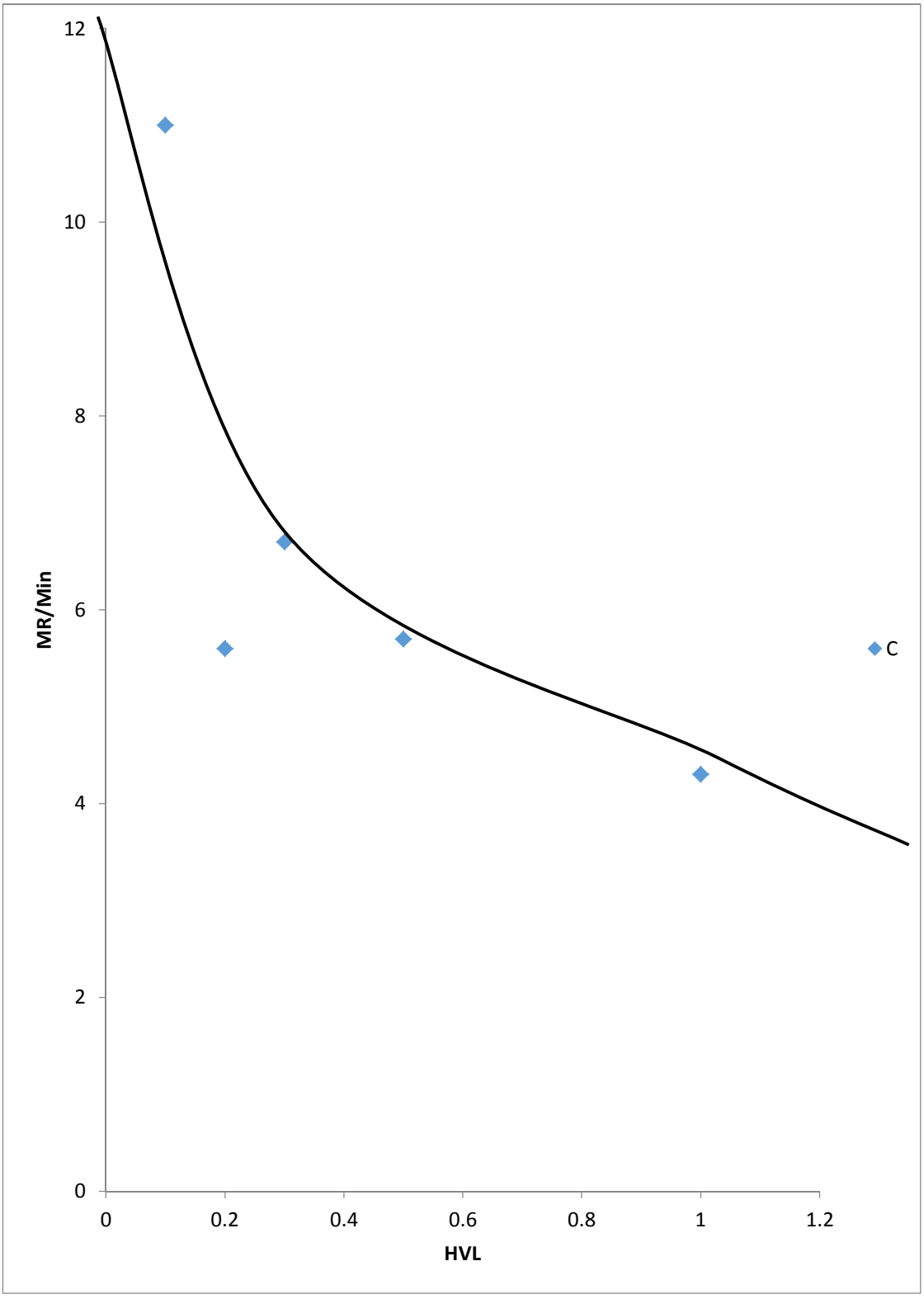


Fig. 4.4 Showing the HVL of hospital C graphically

The graph (A,E,D,C) above show that as the radiation intensity decreases, the attenuating material increases in thickness. Thus the relation of the HVL to the total filtration in the beam depends on the kVp and the wave form of the x-ray generator output.

But HVL of hospital B shows variance due to the fluctuation in voltage output and age of the machine.

4.3.5 Collimator and Beam Alignment Test

The collimator is the beam restriction system responsible for regulating the size of patients anatomy exposed radiation during examination. An increase in the beam size could result in larger scattered radiation and exposure of patients to higher or unnecessary or repeat exposures. The light-fields and radiation field congruence test is one of the factors used for evaluation. It measures how well the collimator regulates the radiation field size – that is the correspondence of the area illuminated by the positioning light and the area exposed on the radiograph. Misalignment can be caused by shift in the collimator mirrors or fault in the shutter mechanism. The tolerance limit for congruence should be within 2%.

For a simple beam alignment test, collimator test tool model 161B in conjunction with alignment test tool model 162A is used. Model 161B, is a flat brass plate with a rectangular outline white model 162A is a plastic cylinder about 12.25cm (6") tall with 1/6" (6mm) diameter steel ball at each end.

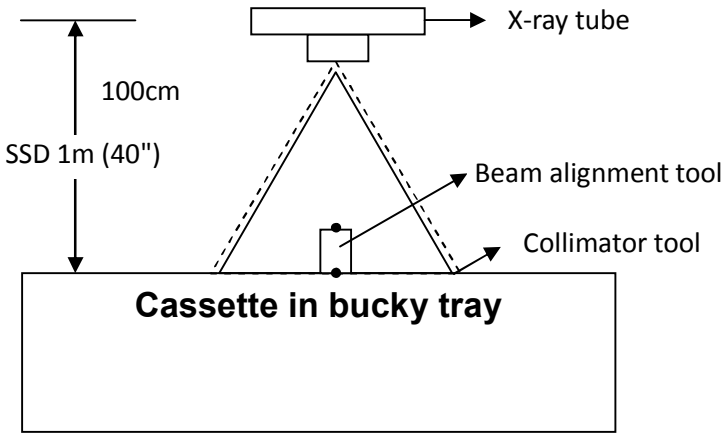


Fig. 4.5 Shows collimator and beam alignment test tool placed for proper exposure.
The following measurements were obtained from the stated hospital.

Table 4.9: Showing results obtained for the Collimator and beam alignment test of the selected hospitals.

Distance between source and light field (table top)	Exposure factor		Hospitals showing Misalignment				
	kVp	mAs	A	B	C	D	E
1	60	12	1.8cm 0.5°- 1°	3.2cm 3°	2.0cm 2.5°	4.5cm Out of range	1.8cm 0.5°- 1°
90cm	60	12	1.8cm	3.2cm Outof range	1.5cm 1.5°	5.0cm Outof range	1.6cm 1.5°

4.3.6 Check for Grid Misalignment

To check for grid misalignment, RMI model 144 grid alignment test tool was used. It is a plastic covered lead blocker containing five (5) large holes with their centers spaced an inch apart. It helps to detect the lateral decentering or tilting of the grid of the radiographic grid with respect to the central ray of the x-ray tube.

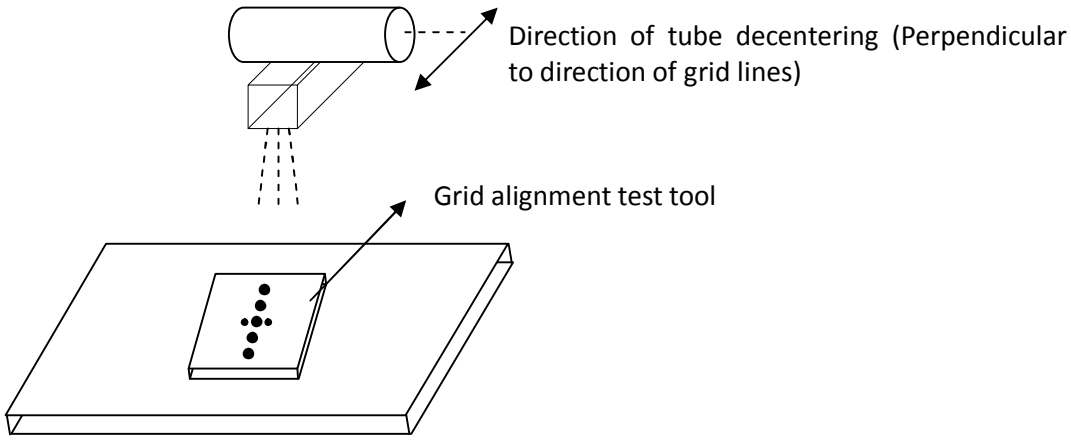


Figure 4.6 shows

The following result was obtained from the selected hospital.

Hospital A

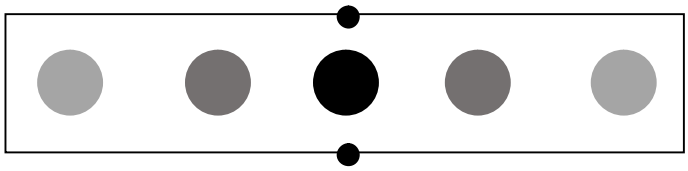


Fig. 4.6.1 shows Grid Alignment obtained from Hospital A

Hospital B

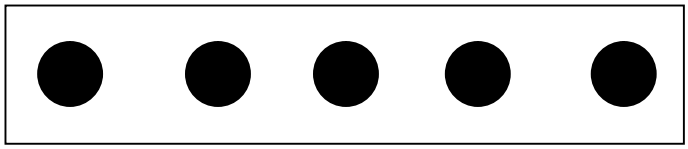


Fig. 4.6.2 shows Grid Alignment obtained from Hospital B

Uncentered grid

Hospital C

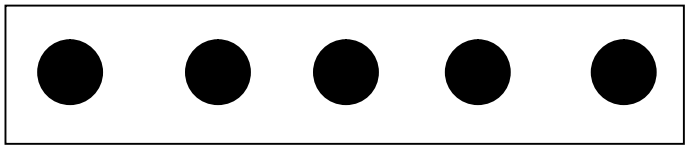


Fig. 4.6.3 shows Grid Alignment obtained from Hospital C

Uncentered grid

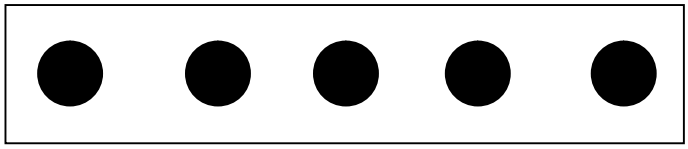


Fig. 4.6.4 shows Grid Alignment obtained from Hospital D

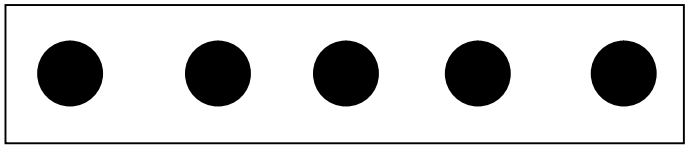


Fig 4.6.5 Shows Grid Alignment obtained from Hospital E

Base on the results obtained from the selected hospitals, hospital A showed a gradual symmetrical decrease in the radiation intensity. While hospitals B, C, D, E showed no sign of radiation decrease in all the holes as shown above. This implies that even areas that are not required to be exposed are virtually exposed hence, rejects leads to retakes.

Grids that are misaligned attenuate primary X-rays causing loss of image quality and higher patient dosage.

4.3.7 Checking the focal spot of Radiographic system

A focal spot test tool mode 112B was used to detect the gradual deterioration in the focal spot before clinical images are affected. The focal spot test tool 112B consists of a metal target with 12 bar pattern groups of different sizes. Each group has six slots, three horizontal and three vertical. The size and spacing of the slots ranges from 0.84 line pairs/mm to 5.66 line pair/mm (Cp/mm) with each group being 16% smaller than the last pair. Exposure is made at factors 55kVp and 8mAs respectively. A large focal spot will resolve only the larger groups, while the smaller focal spot will resolve the small groups.

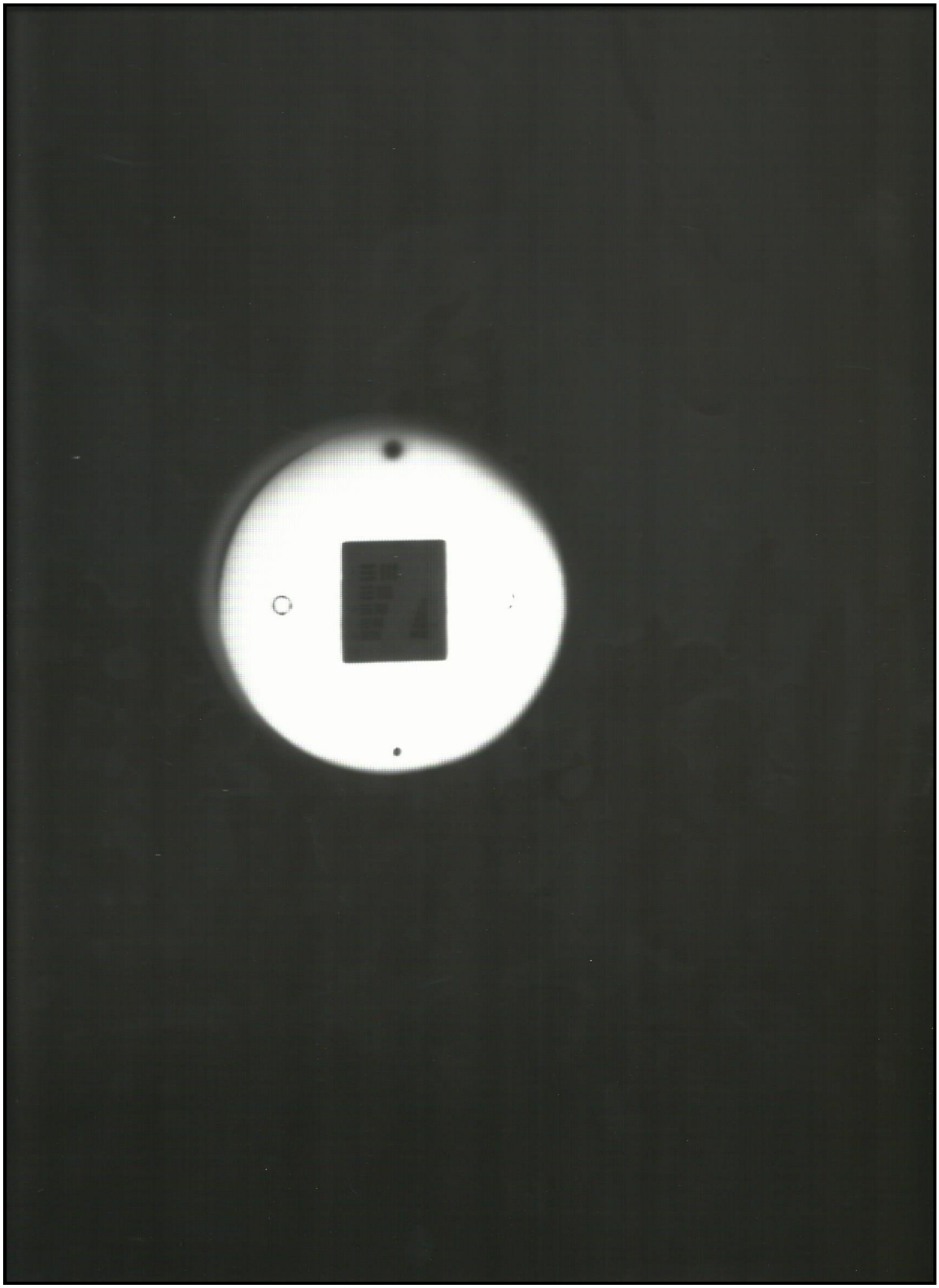
Results of Focal Spot

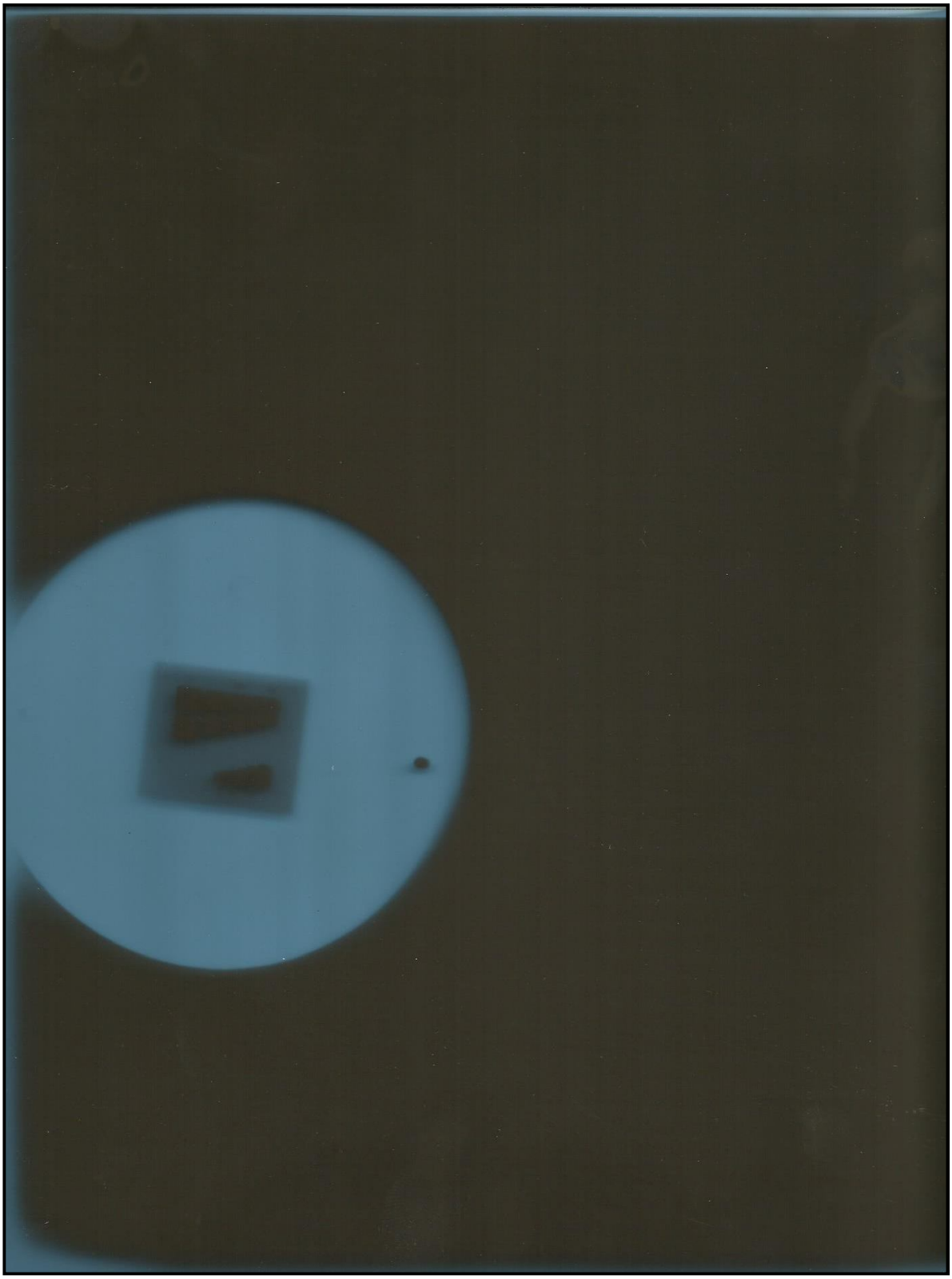
Hospital A

The test tool was placed on the cassette having the film, the x-ray tube was positioned over the test at 100cm (FFd). Exposure was made at 80 kVp and 10mAs for all the foci, the radiograph was processed and scanned. The larger focal spot which correspond to a nominal focal spot of 1.8mm resolve only the large group i.e. only 5 groups of bars was resolved while the small focus which corresponds to 1.5mm resolve 6 groups clearly.

This implies that the nominal focal spot supposed to match with the rating focal spot written on the X-ray tube. In the case of hospital, the rating of focal spot is 1.0/1.2mm. Thus an X-ray tube of some particular rating are expected to resolve up to the

corresponding bar-groups, if not, the radio diagnostic information required will not be obtained which will call for retake or rejects of the films exposed and hence unnecessary exposure.



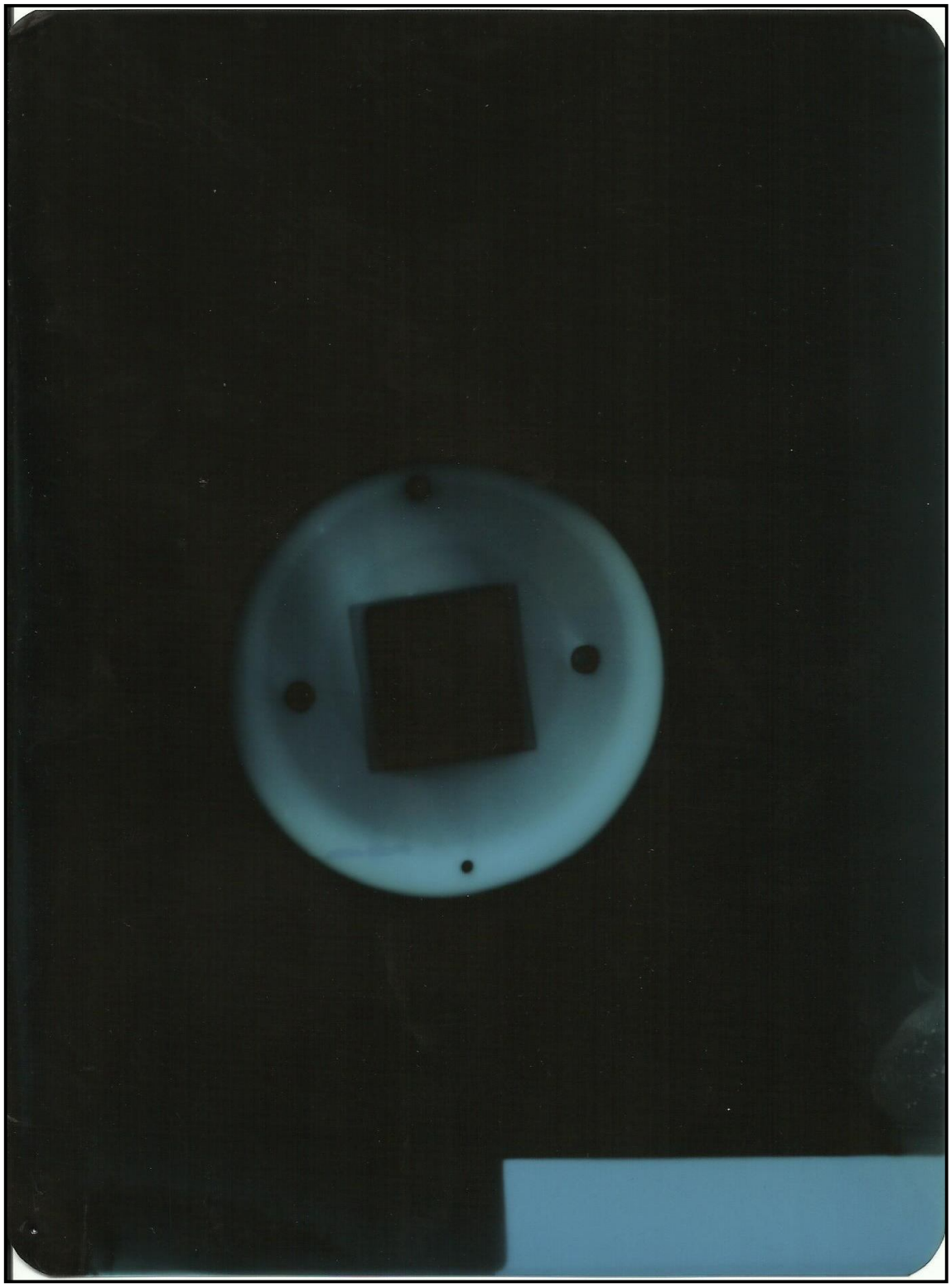


Hospital B, C, D and E

The focal spot of the stated hospitals could not resolve the bar patterns clearly. This implies that the machine is either improperly fixed or is over aged. So a wider coverage of image size may be obtained or exposing other areas of the body that are not required.

The end results of such films is rejected and or re-exposure of the patient again and again. The tube rating is not stated.

According to Rehani (1995). Any X-ray machine that focal spot size 1.0/0.3mm respectively, gives a wider coverage of image, sizes which may result in exposing others that are not required.



In essence, a small focal spot yield more detail in a radiograph. The ability for resolving the smallest size of the image in a radiograph depends upon the target size. It is important that large parts of the body such as chest and abdomen are radiographed. It's periodical evaluation is important to ensure the focal spot size and shape are not altered as a result of bombardment of electrons on the target.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Mechanical Assessment of X-ray Equipment Operation

The physical operation of the x-ray equipment is one of the most important parameters in QA/QC checks. The mechanical parameters of the equipment were checked as presented in table 1. It is obvious that some of the machines' parameters were not good from the operational point of view, at this point, based on the hospital facilities/utilities, recommendations was made in order to eliminate or adjust were necessary. X-ray and light space at the selected hospitals were not the same, especially in hospital B and D, this leads to the need of repeated exposure which could consequently increased patient absorbed dose.

Basically, as represented in table I, the room dimension of hospital B and D is out of allowed range, no localizing light and shield. The beam and collimator light are not available, the radiographers or technicians in hospital B collimate the spot size for exposure with his bear hand for perpendicularity. This implies that, since there is no collimator light, the part of the body of the patient not requiring examination may be exposed to radiation.

The inherent and tube filtration of the machines in the selected hospital, were not the same.

The Kilo voltage across the X-ray tube varies in intensity which affects the X-ray output and image contrast. The voltage output in Hospital A was found to be within the tolerance limit of the range stipulated by ICRP which is ±0.05% while the kVp findings at hospital B, C, D and E showed variance to that effect. For Hospital B, it was 0.55% indicating that the kVp across the tube is high compared to the allowed implying high exposure of radiation to patient. That is the percentage variance is 55% which is far above the limit. At both high

and low kVp set, the output being the same means whatever the setting or body size same radiation is emitted. Effort was made to set the kVp at different voltage but still the output was the same. For hospital C, at 60 low kVp the output showed consistency with the allowed limit provided by ICRP, but at 70 and above kVp` etc. the coefficient of variance showed that the radiograph under exposed the patients. (Table II). Though, the coefficient of variance is 0.14 i.e 14% the machine control panel have mechanical faults. Measurement lower than 60kVp is not possible for hospital B and C.

For hospital D, measurement could not be done by varying the kVp settings because, the machine was set at fixed kVp and the engineer instructed the technician not to vary or reset both mAs and kVp. So measurements at the fixed 80kVp for both young and old (or at any body size) patients may be over exposed or under exposed which could lead to reject and hence unwanted and unnecessary over exposure.

In hospital E, the kVP output from 60, 70 set kVp were fine but at 80 set kVp, patients are under exposed the percentage difference is -8.4%. At numerous reading, it showed the output under exposure, thus exposure at set kVP are not true reflection of emission therefore the machine needs adjustment to avoid under exposure and possible rejects leading to retake which could lead to unnecessary and unwanted over exposure..

The check for the accuracy of exposure time was only possible in hospitals A and C with coefficient of accuracy 82% and 83% respectively. While the remaining three hospitals had no mA setting on their control panel which makes it impossible to evaluate. This implies that eradication exposure at these hospitals could be very dangerous since the duration it takes for exposure cannot be determined. Thus, the hospital, need to change the panel or attention of the x-ray maintenance or engineering.

In all the selected hospitals, the film-screen contact check showed that, at 70kVp, 5mAs using 17/14 film sizes, the images were fairly clear and had a uniform density by observation. At 60kVp, 4mAs, using 14/14 film size, the image was also fair with uniform density by observation. But at 50kVp and 4mAs using 17/14 film sizes, the image had poor contact showing dark areas, this implies that at 50 kVp, 3mAs 17/14 film size is not advice able because the image will be difficult for radio diagnosis analysis which could therefore call for repeats because of rejection of films and hence rejects or retake which will lead to unwanted and unnecessary over exposure of patients.

For grid alignment check, hospital A had good grid alignment with the middle hole, showing the greatest density of the radiation intensity. This implies that, there is no scattered radiation and only the portion needed to be exposed received the required intensity.

While hospitals, B, C, D and E showed grid misalignment because all the five holes of the test tool received the same intensity of radiation. This implies that, the portion required for exposure and the surrounding parts of the body closed to that portion not requiring examination also received the same radiation intensity. This leads to an unnecessary and unwanted exposure of parts not needing examination to exposures.

Over exposure due to human factor was found to be another major problem in almost all the hospitals used this could arise base on the radiographers' qualifications possible training. Only hospitals A, C and E had qualified radiographers while the remaining two hospitals (B and D) had just technicians converted to do the work of radiographers with little or no trainings.

On record keeping, only hospital A had Q_A/Q_C records but the others have no record of Q_A/Q_C and x-ray machine maintenance services program.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

There is little or no Q_AQ_C checks in the various radio diagnostic equipment of the radiology department of the hospitals selected. Though put through the same kVp settings, the linearity of exposure times in most of the hospitals could not be measured, because there was no mA scalings on the equipment control panel.

Two of the hospitals (B, D) selected have aged x-ray machines which resulted in having poor film screen contact, poor beam and collimator alignment and, poor or bad grid alignment. This resulted in reduction in mage quality, encouraged rejection and hence repetition, increased breakdown or increased cost of maintenance as well as unnecessary and unwanted over exposure of the patients, workers and maybe relation helping to station and hold the patients for the examination.

In the hospitals, selected, measurement showed that exposure at 50kVP, 10mAs is not possible, thus it is advised that exposures at 50kVp should be made at low mAs (3-4mAs). To avoid distortion of images, any field alignment greater than 3cm at 100cm source to image distance should not be acceptable. This implies that the misalignment is approximately 3^0 away from perpendicularity.

Finally, from all the hospitals stated, the study varying level of adherence to guideline were evident with no hospital demonstrating complete compliance to NNRA standard guidelines that is needed to avoid retakes which are ± 5% for kVp out put limit,2% for beam congruency and alignment. Focal spot should resolve within 7-8 lines pair, with degree of blooming should not be less than 70%, HVL at 80 kVp should be ≥2.5mmAl. Thus

hospitals that are outside limit should be made to do routine Quality control (QC) on their radiodiagnostic equipment

6.2 Recommendations

There is great distinction between the purposed built hospital and un-purposed built hospitals. Hence the following are recommended

1. There should be workable maintenance program, and an agreement with a reputable well training engineer to ensure that the X-ray machines are routinely checked and working well.
2. Further work should be done in the area of equipment output as a function of use.
3. To reduce the incidence of unnecessary and unwanted over exposure due to rejects and hence repeat x-ray equipment that has over stayed should not be used for the routine procedure, because, age of the machines contributes to the grid misalignment, poor film-screen contact etc and hence should be replaced with new ones.
4. A radiation protection program which will include Q_A/Q_C of the equipment and appraisal format should be set for un-purposed hospitals, to ensure that standards are maintained consistently and unnecessary and also unwanted exposures checked and corrected.

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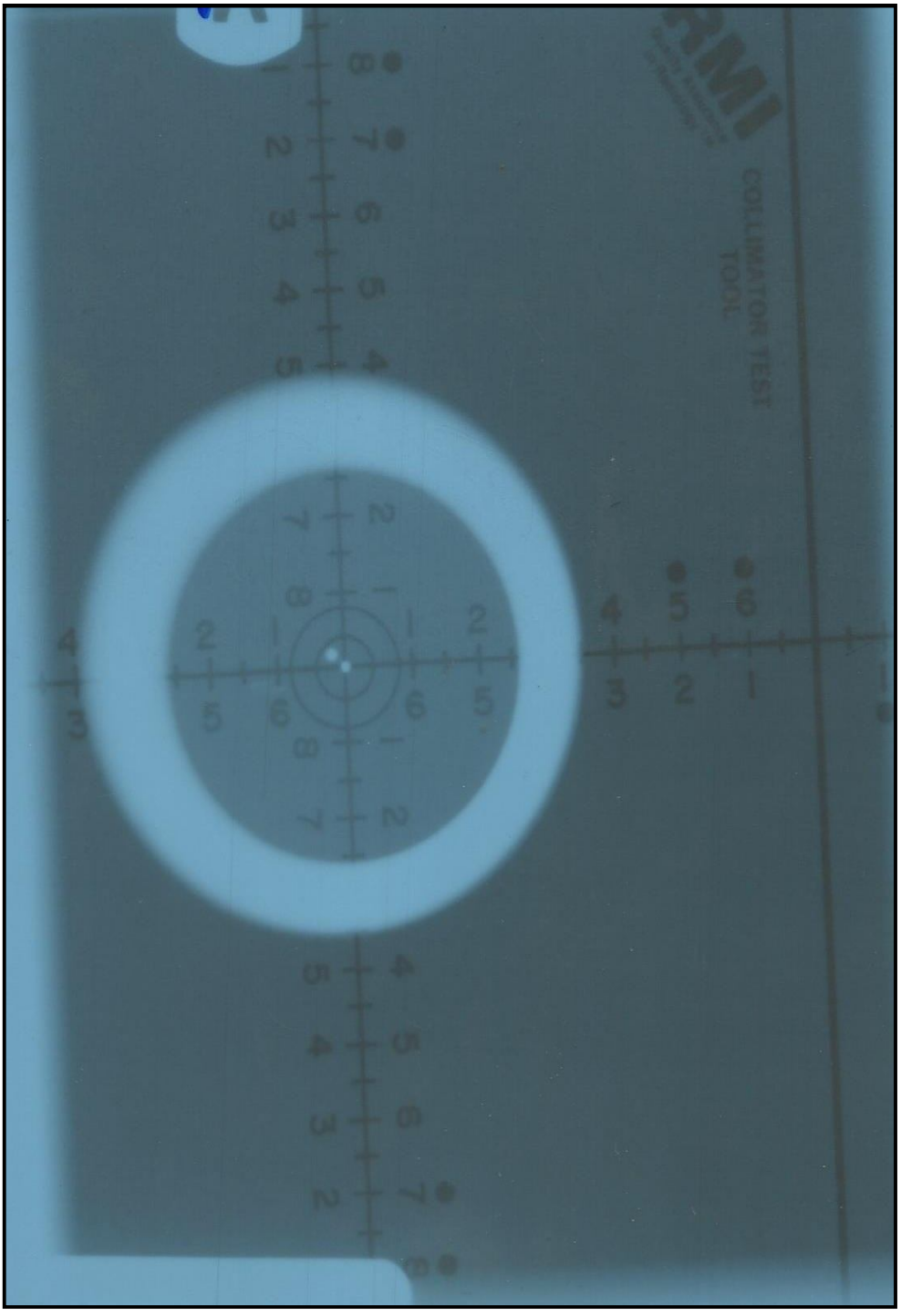
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APPENDICES

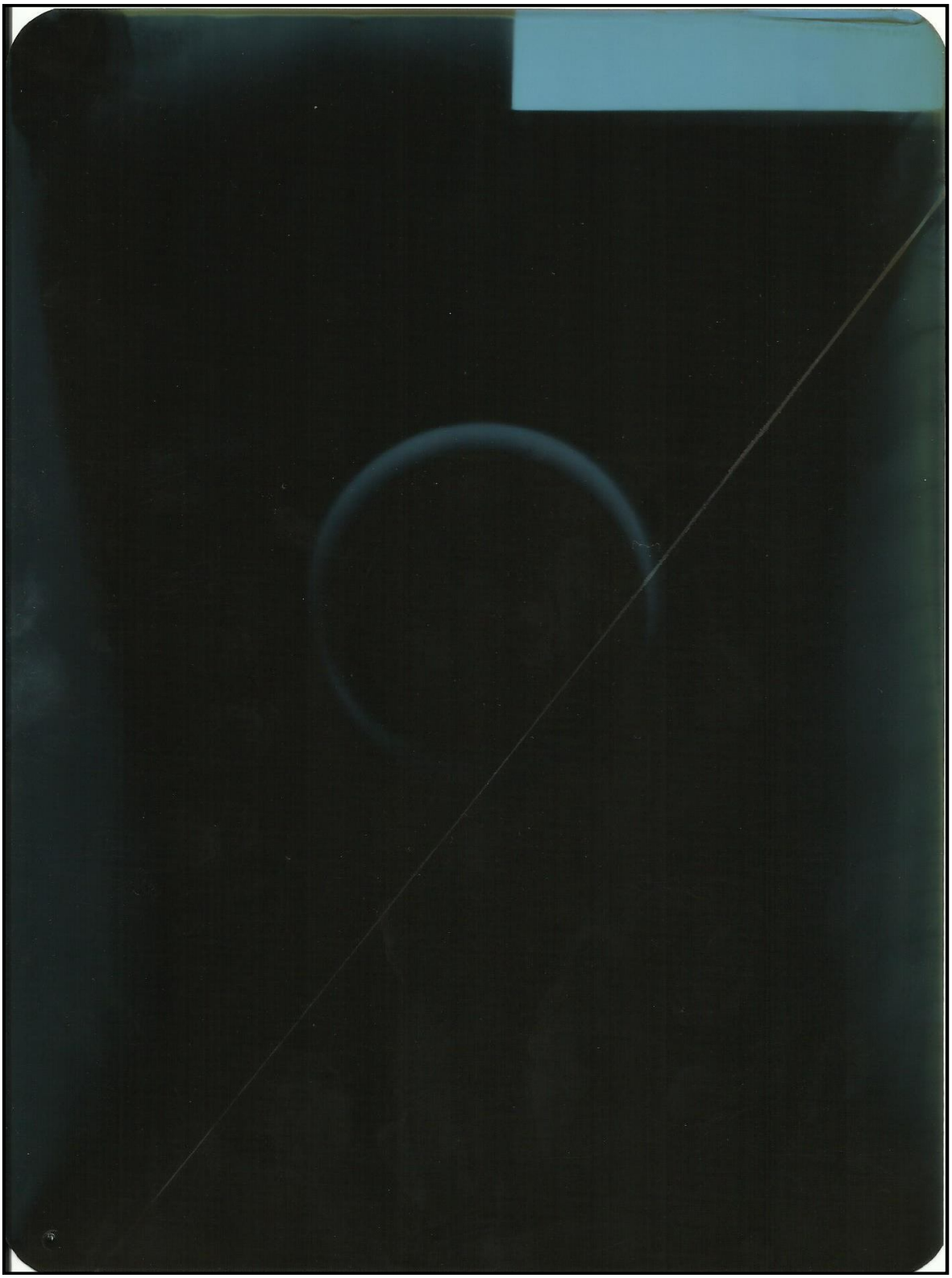
APPENDIX A

COLLIMATOR AND BEAM ALLIGNMENT TEST

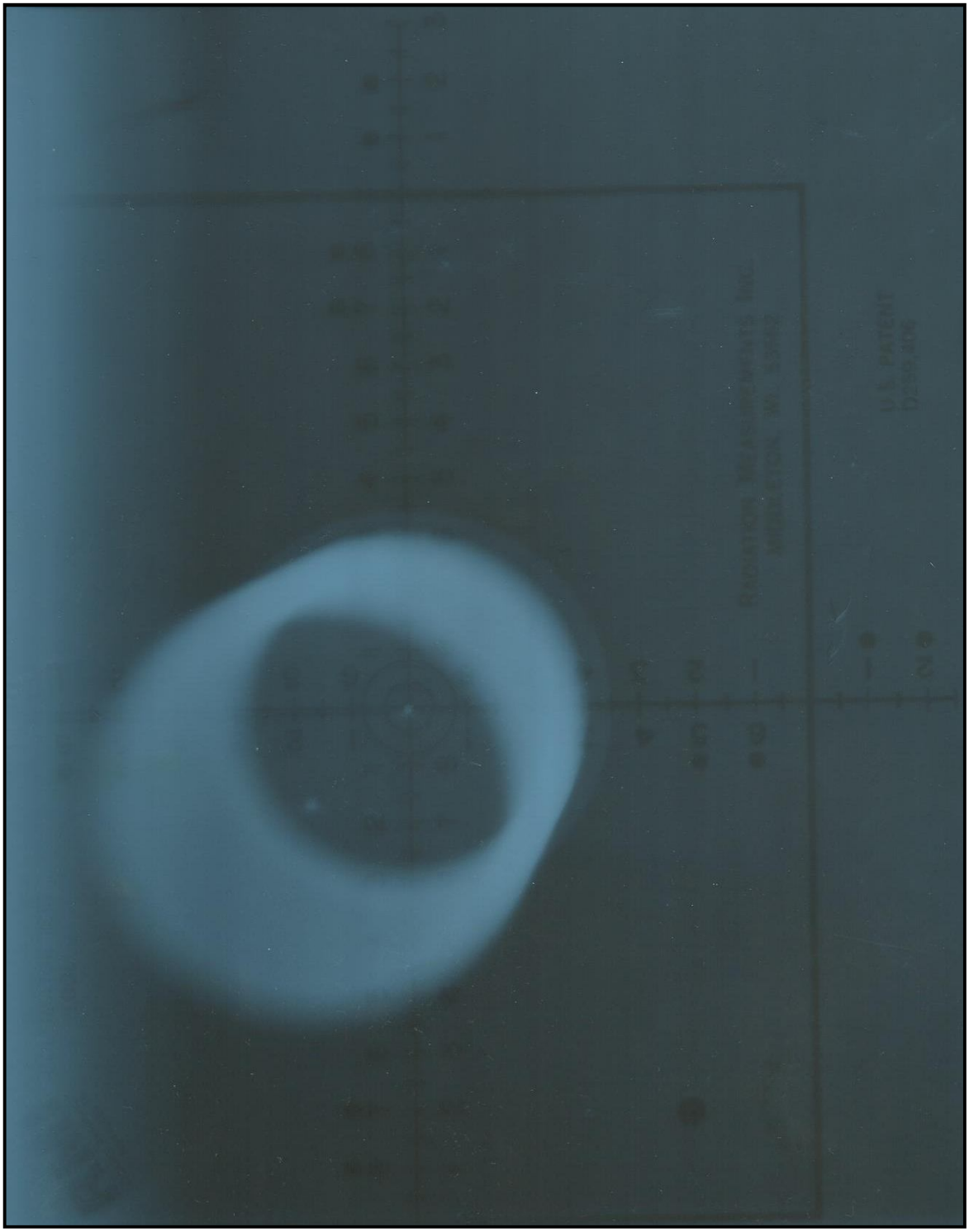
Hospital A



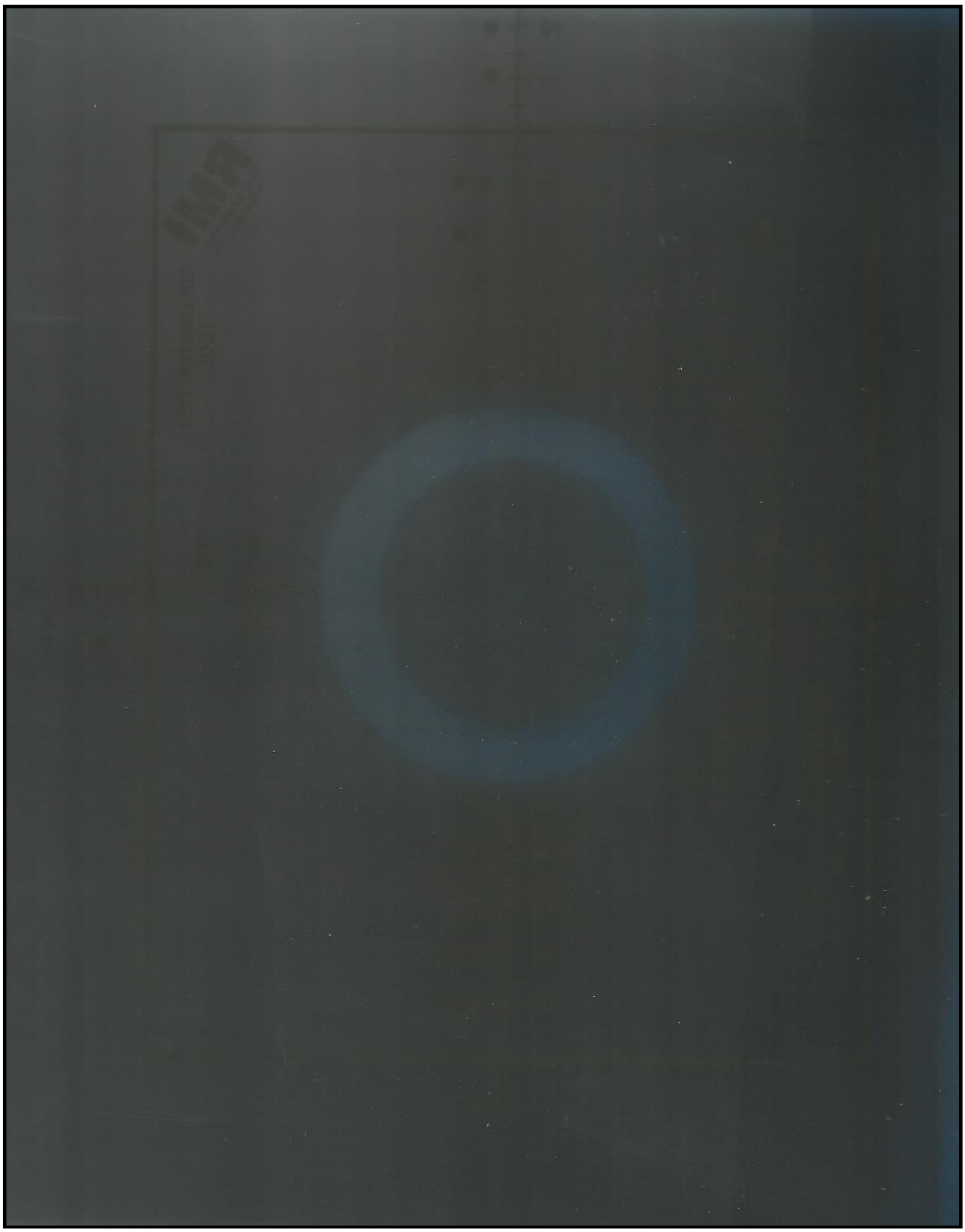
Hospital B



Hospital D



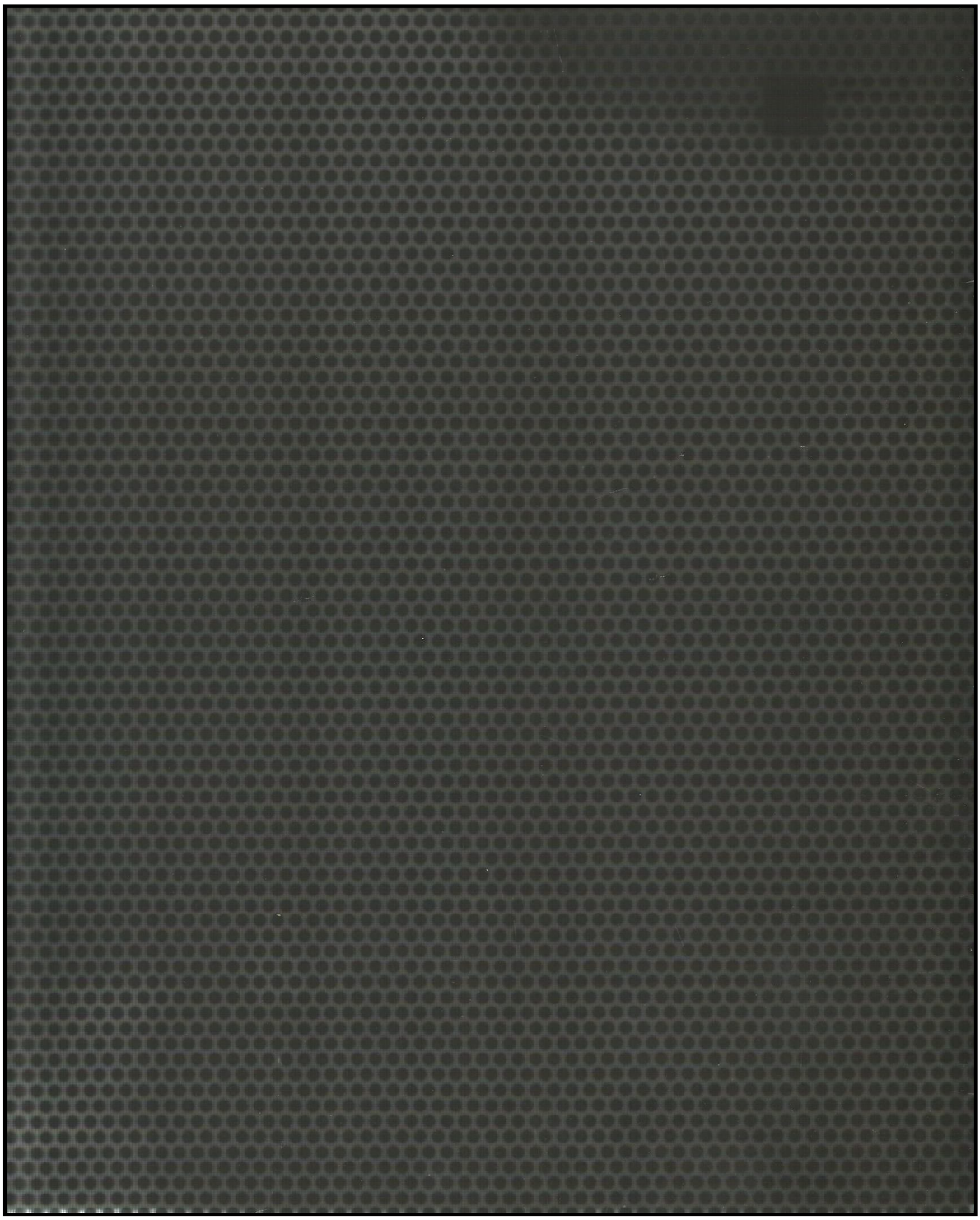
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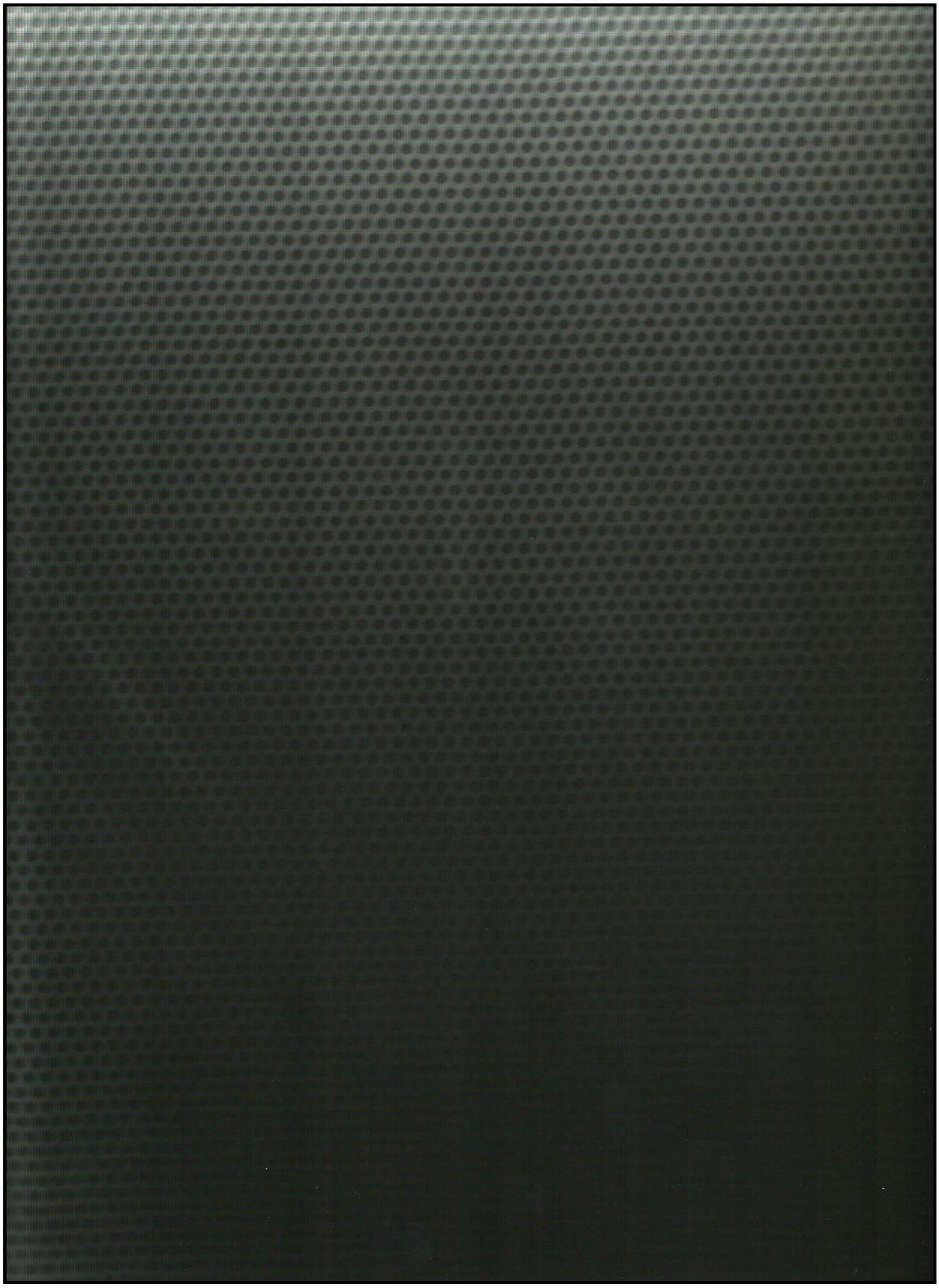
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FILM-SCREEN CONTACT TEST TOOL

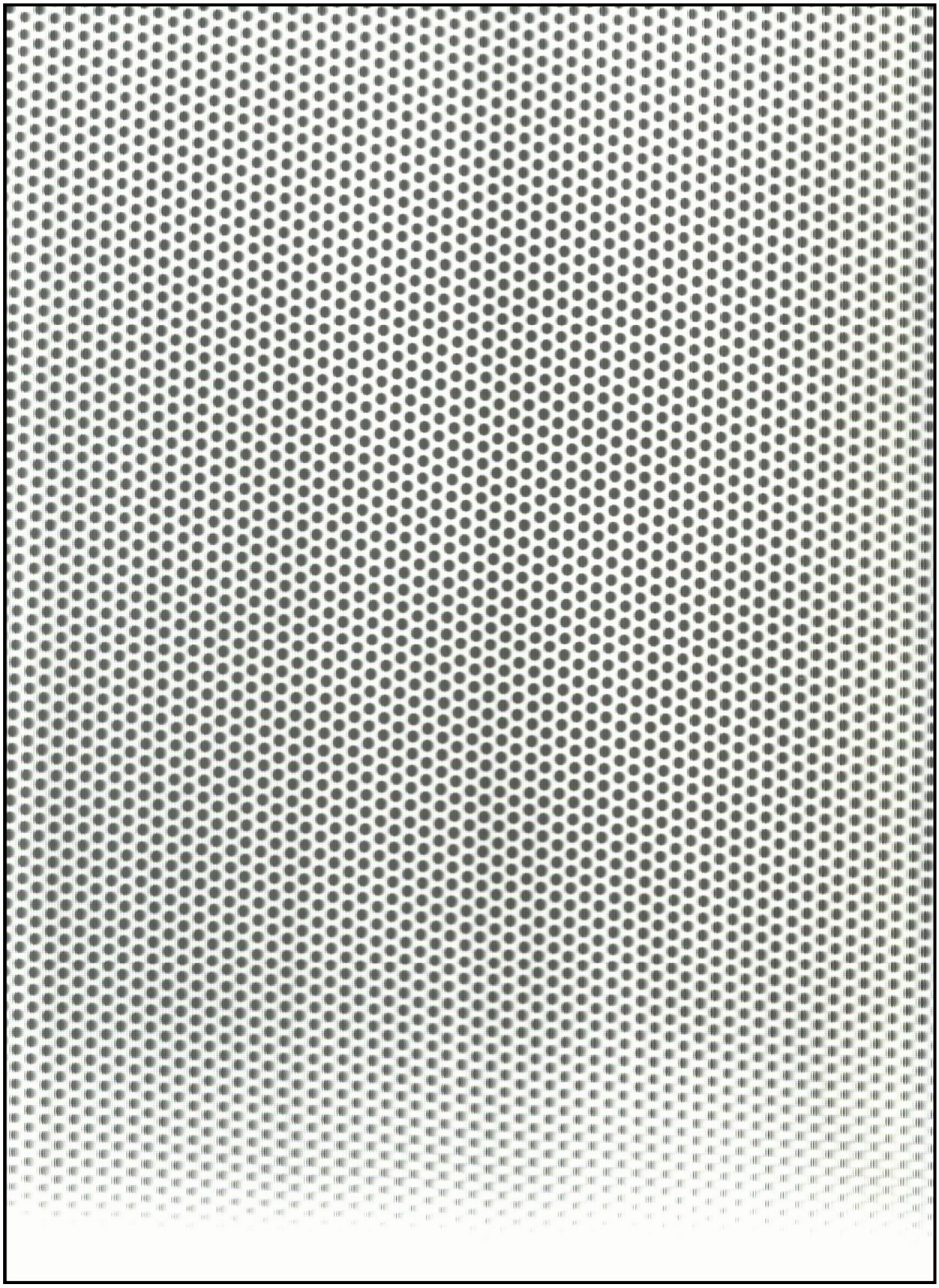
Hospital A



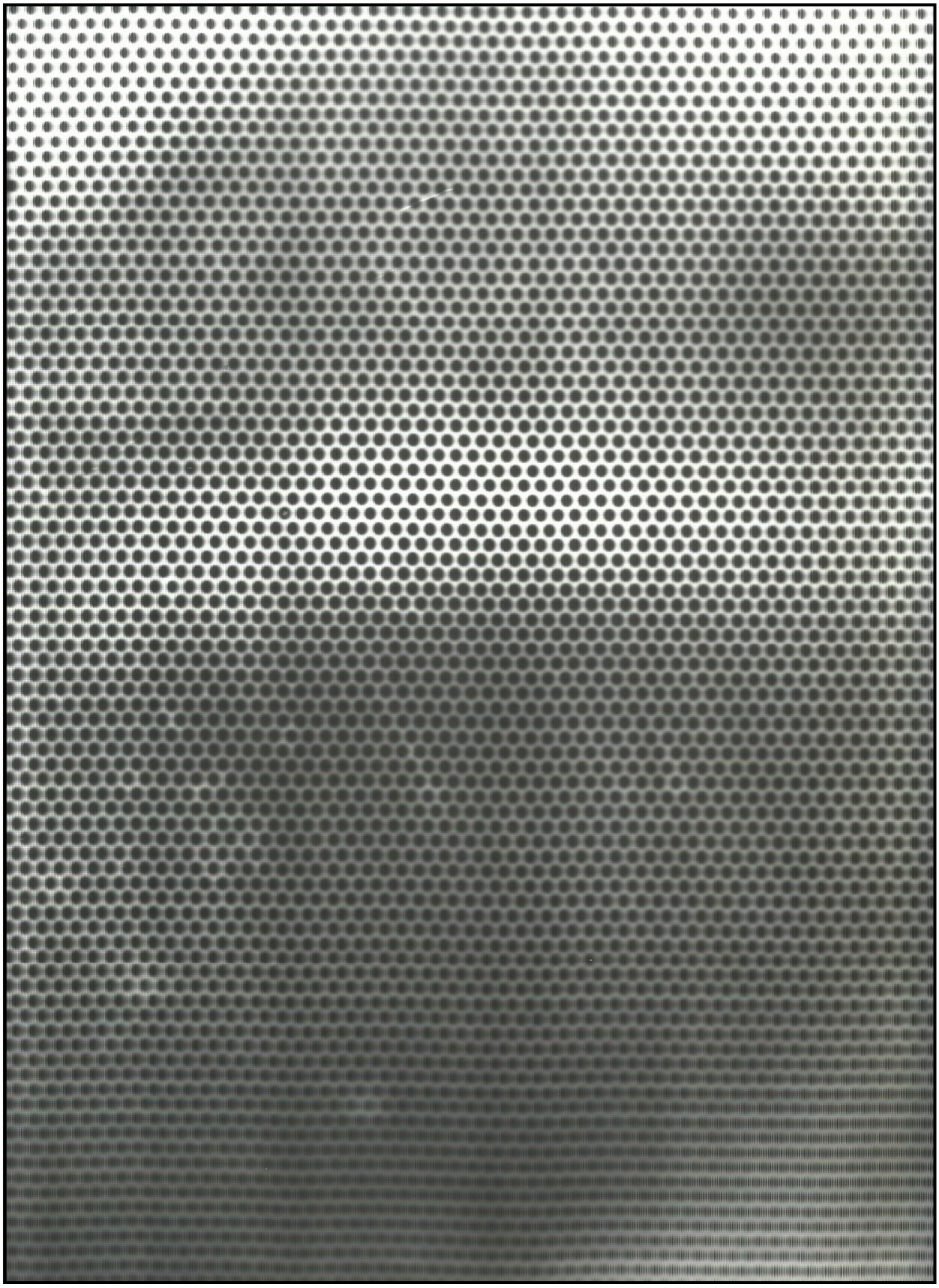
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Hospital D



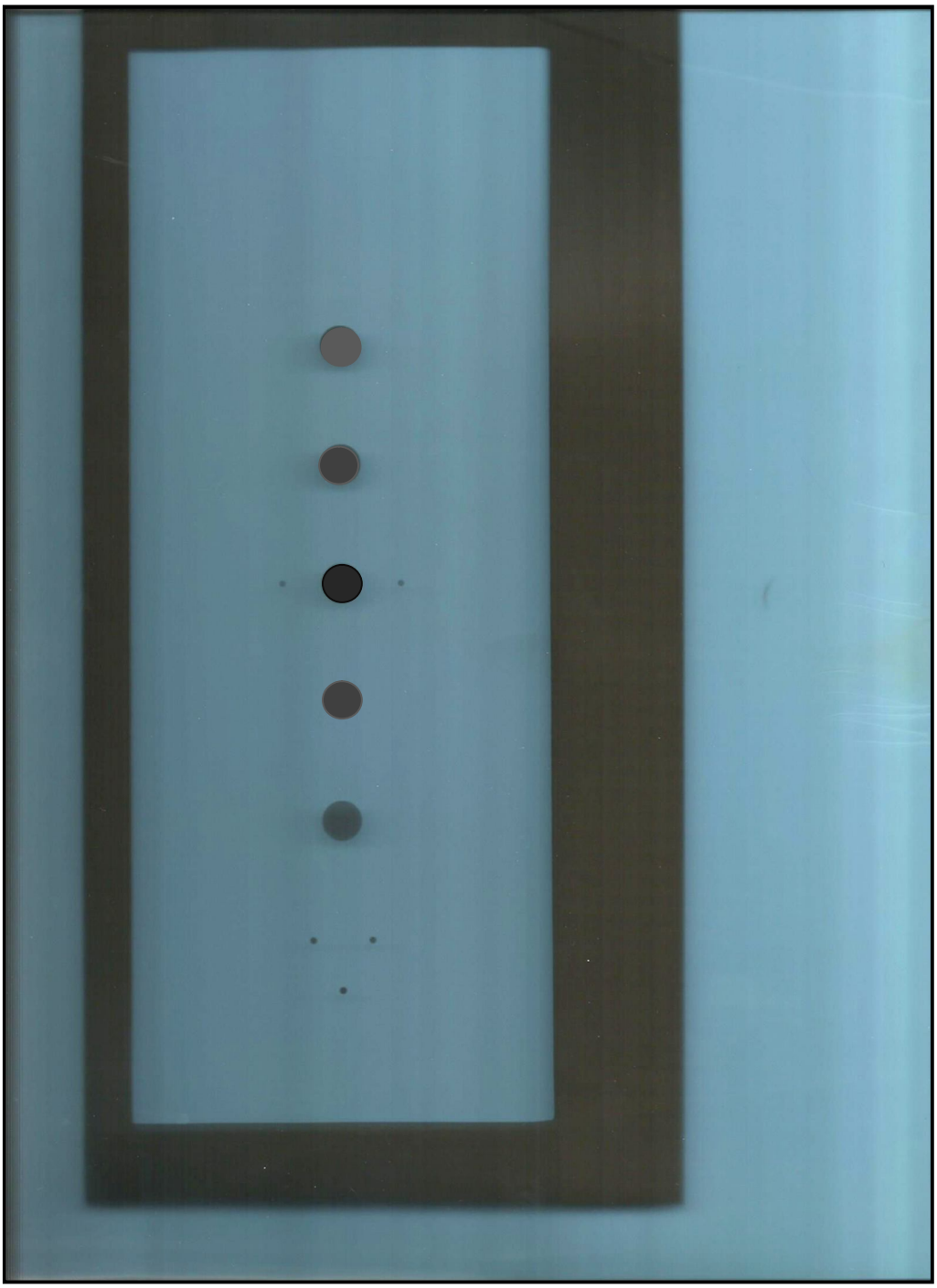
Hospital E



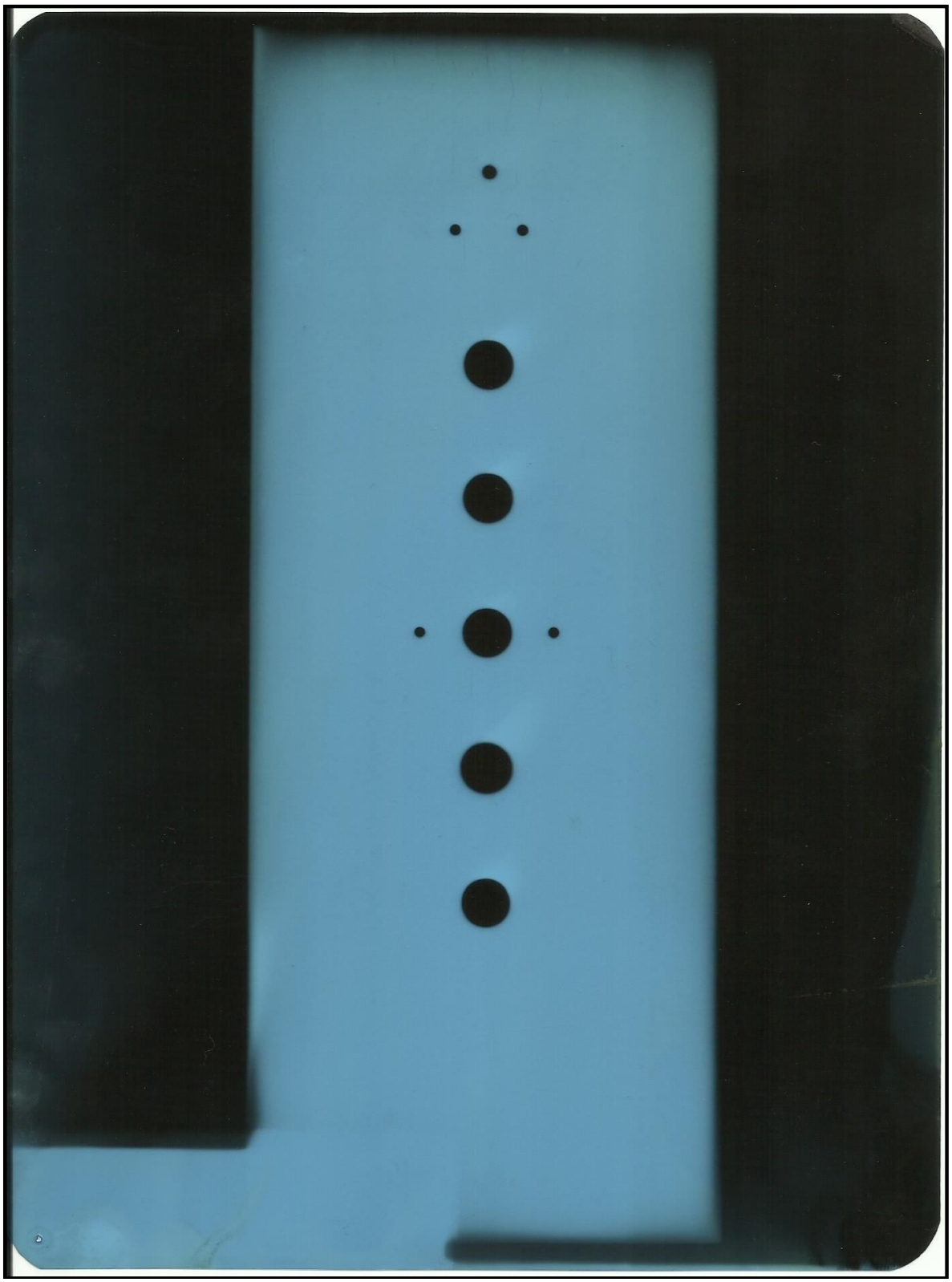
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GRID ALIGNMENT TEST

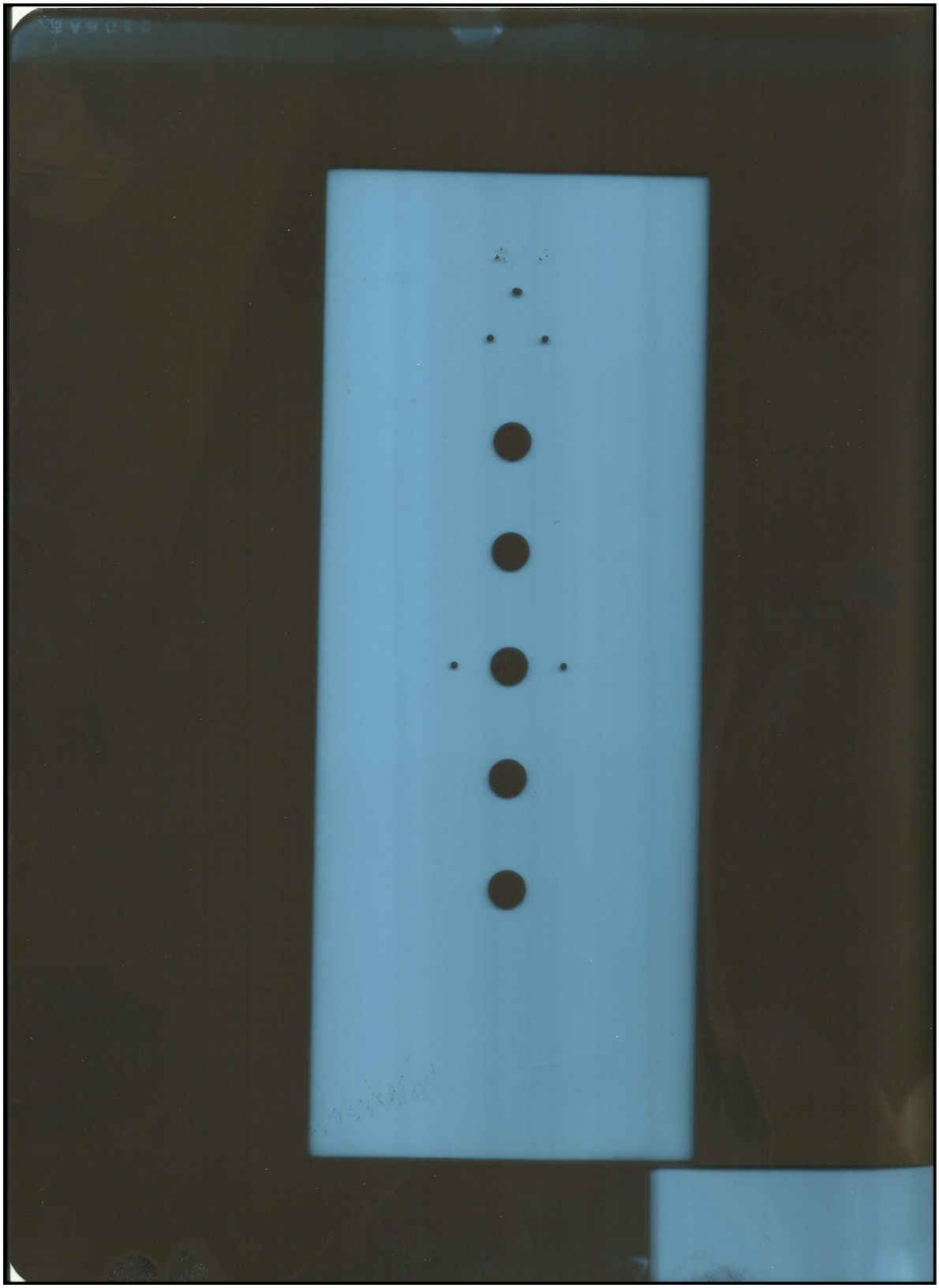
Hospital A



Hospital B



Hospital D



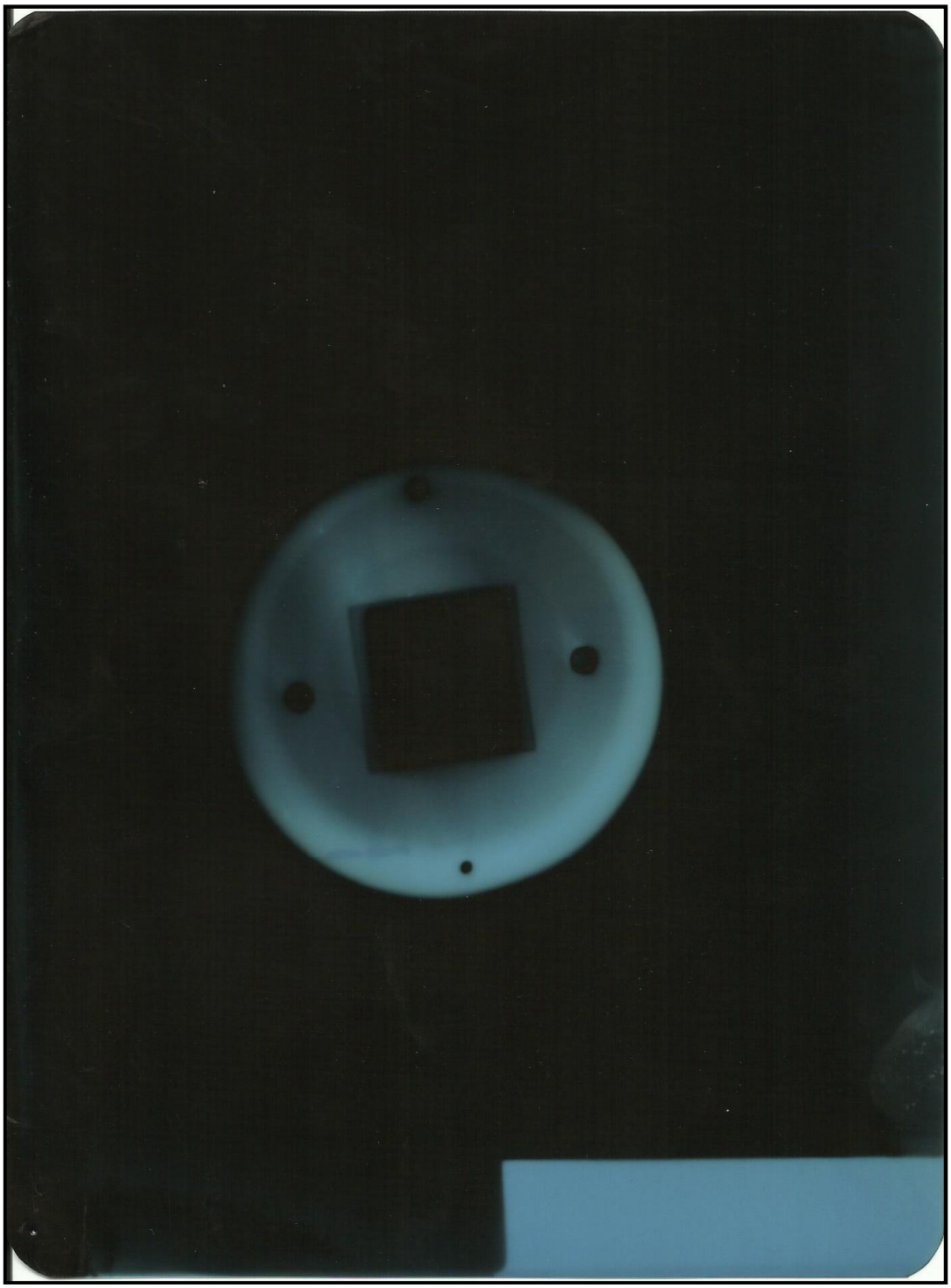
Hospital E



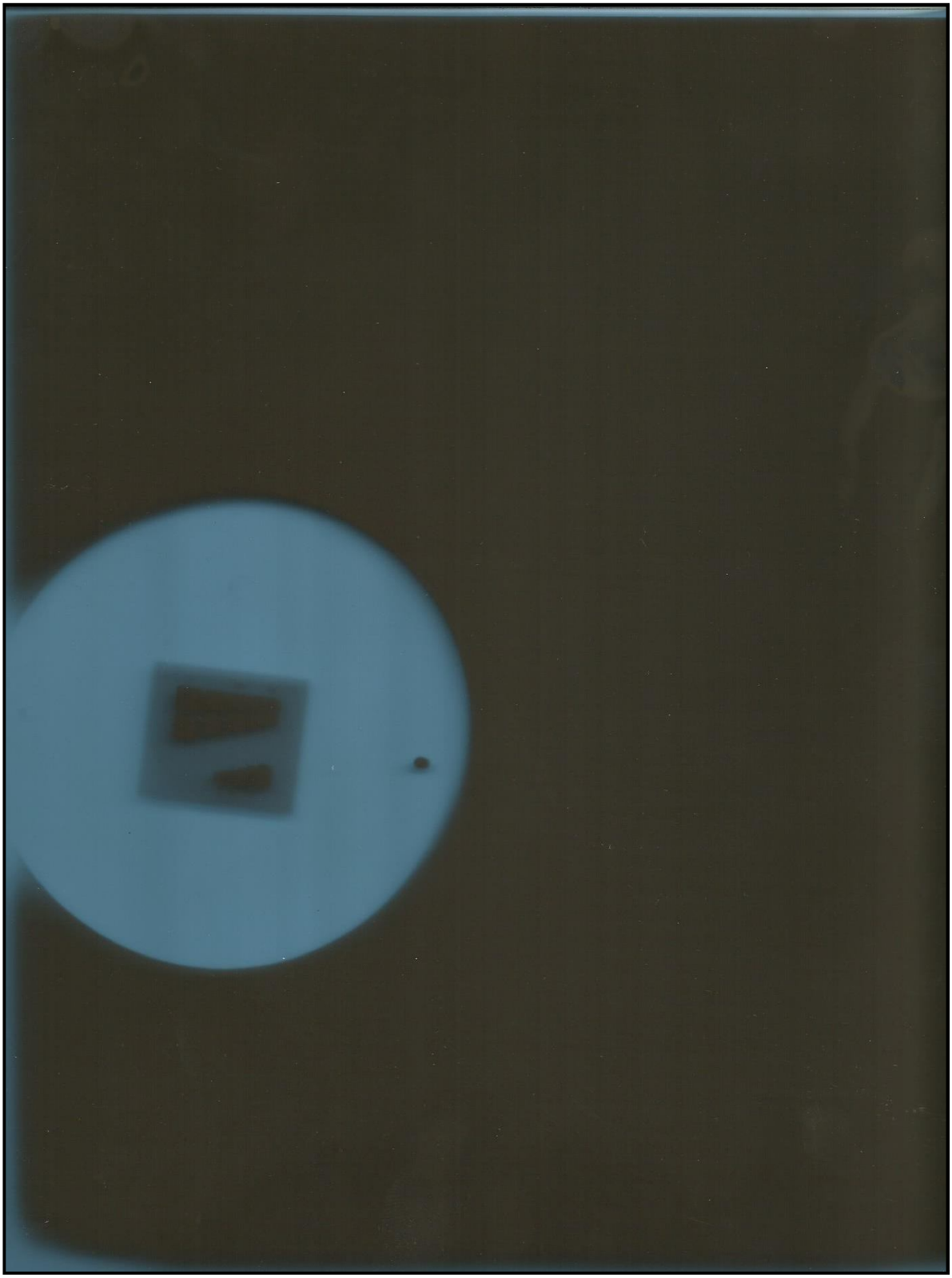
APPENDIX D

FOCAL SPOT TEST

Hospital B



Hospital D



Hospital E

