SELECTED PROBLEMS ON RADIATION SHIELDING

THESIS

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By

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بسم الله الرحمن الرحيم

CONTENTS

SUMMARY

This thesis is divided into two parts :
Part I , is devoted for - the determination of the characteristics of radiation outputs from the X-ray machine (TUR.T. 250 KV) for different radiation qualities.

The qualities used are of H.V.L. 2.4 up to 5.0 mmAl and 0.66 to 1.94 mmCu. These H.V.L. were obtained by keeping the K.V.P. applied constant for different added filtrations (using the Siemens H.V.L. apparatus).
Phantom used was made of bees-wax which represents body tissues.

In this part of the thesis the following items were studied :

1 - The effect of tube current (in MA) on dose rate (in r/min). It was found that the dose rate does not increase linearly with tube current, while the ratio of dose rate outputs at two different tube currents is constant.

An exponential decrease of dose rate with the increase of radiation quality was observed. It is suggested that this exponential decrease is given by the impirical formula :

$$D_{I_1} = D_{I_2} \, e^{-\left[\frac{I_2}{I_1} (H.V.L.)_{cm}\right] K}$$

where K is a constant that depends upon K.V.P. applied. It was found to be 1 , ¾ and ½ for 80 , 100 and 120 K.V.P.

2 - The effect of field size on dose rate out put : It was found that for all radiation qualities used, dose rates rise rapidly at first as the field size increases up to about 192 cm^2. This increase continues at much slower rate for larger field sizes.

The H.V.L. of the inherent filtration of each K.V.P. applied was deduced.

The main aim of the measurements is to study the shielding properties of a variety of homogenised hydrated portland cement compressed at various loads and one type of naturally occurring Egyptian ores namely Haematite.

The scheme of experimental measurements performed includes:-

Measurements of percentage dose rate transmission at different positions to idendify the heterogenity present in each of the samples used.

Calculations of attenuation curves plotted as relations between r/ma min at 1 m and absorber thickness (mm Haematite and lead). From the curves, a table of lead - Haematite equivalents over a selected range of radiation qualities was prepared.

From the transmittion curves it was possible to deduce the equivalent half thickness (i.e. the thickness which reduces incident intensities to half their values. From these values, the mmCu and mmAl equivalent to 1 mm Haematite was deduced. This proved that Haematite is a better shielding material than Al but it is worse than cu.

Thicknesses required to reduce transmitted intensity to 1% and 10% of incident intensity, were deduced.

The H.V.L. equivalent was used to calculate the linear absorption coefficient (μ) of the material of sample used.

From the calculated values of specimen density ($\rho = \frac{m}{v}$) where m is the mass of the sample in gm and v its volume in cm^3 ; the mass absorption coefficient ($\frac{\mu}{\rho}$) of the sample was calculated. For portland cement μ/ρ values are lower than that of Haematite.

it follows that portland cement of the available structure is not recommended as a shielding material, through it may be of good building characteristics.

The relations between μ/ρ and equivalent k.e.v. were plotted.

The Haematite ore was analysed spectrographically (for qualitative analysis) and by chemical methods (for quantitative estimations). Portland cement data were obtained from chemical analysis and speculation was suggested by professor R.S. Mikhail. This information was used to calculate the effective atomic number ($\bar{\bar{Z}}$) of each sample. It is resonable to suggest that hydrated Portland cement is a satisfactory material as an analogue of Al whose effective atomic number is equal to that of the sample.

An empirical relation is suggested relating the μ/ρ of the investigated sample and the usually accepted shielding materials - (such as lead) - at a selected radiation quality, and the corresponding $\bar{\bar{Z}}^{2.94}$ values. μ/ρ of any material at this quality can be determined if its n_o value is known.

Part II of this thesis contains, a comparison of the absorption measurements of the X-ray beam through the Portland cement samples were made between values obtained using film dosimetry and ionisation chamber method for different radiation qualities (2.4, 3.0, 5.0 mmAl and 0.9, 1.94 mmCu).

Measurements lead to lower absorption coefficient values using the film dosimetry technique. This is attributed to the inherent error encountered in film dosimetry.

Mean values of H.V.L. deduced using the photographic method were compared with those obtained using the ionisation method. The values were found to differ slightly but no constant conversion factor can be suggested specially for soft radiation.

CHAPTER I

Introduction.

Determination of H.V.L. for X-ray beam.

Aim of research.

(1.1) The history of protection from hazards of ionizing radiation:

The history of biological damage by ionizing radiation is almost as old as the history of X-rays[1]. The first case was reported in July, 1896, within a few months of their discovery by Roentgen, and two years before radium has been separated in a pure state by the Curies. Attempts were soon made to set up safety rules for the newly - discovered radiations. The first of these attempts was by Rollins, who suggested that "if a photographic plate is not fogged in seven minutes, the radiation is not of harmful intensity". This proposal (which incidentally hints at the difficulties of measuring the intensity of X-radiation at that time) is now thought to be insufficiently stringent by a factor of about one hundred.

The greatly increased hazard during the 1914-1918 war led Russ to propose an organized system of protection. Unfortunately, very little was done to put his suggestions into practice, and as a result a large number of cases of aplastic anaemia were reported in the years immediately following the armistice.

The British X-ray and Radium Protection Committee was formed in 1921, with the purpose of establishing adequate standards of protection for all persons exposed to radiation hazards. It published its first recommendations in July of the same year. An American Committee formed by the American Röntgen Ray Society in 1920 published a some what similar set of recommendations in 1922. From then on the apathy towards the problems of protection disappeared.

The first International Radiological Congress was held in London in 1925, and set up two commissions to report on units and protection. As a result of their recommendations, the second congress (Stockholm, 1928) adopted the first internationally recognized unit of dosage – the roentgen. The International Commission on Radiological protection (I.C.R.P.) was organized in 1928 to deal with the problems of X-ray protection, and early in 1929 an Advisory committee on X-ray radium protection was organized within the United States. In the remaining eleven years before the outbreak of the second World War a mass of evidence regarding permissible exposures was accumulated. Subsequent experience of X- and gamma radiations has so far led only to minor modifications of 1939 standards.

Fortunately, the magnitude of the task has itself produced the climate of opinion necessary for the efficient operation of protective measures and led to the emergence of a new profession, that of "health physicist" (a term which appears to have originated in Los Alamos in 1942). According to Parker : "Health physics" is a border line subject. In general it is concerned with the physics and biophysics involved in the interaction of radiation with the human body, with special emphasis on the protection of radiation workers against the potential hazards of their occupation.

The Advisory Committee was reorganized in 1946 as the National Committee on Radiation protection and measurements (N.C.R.P.). On January, 8, 1957, the National Committee on Radiation protection and measurements has prepared a set of guides. Furthermore the International Commission on Radiological protection has made minor changes in their recommendations.

In general all of these Committees are concerned with the dangers from which the worker with radiation has