

X-ray Protection Using Mixture of Cement Shielding with Barium Sulfate

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Abstract

This study aims to investigate a way to reduce transmitted x-ray through cement shielding. A cement shielding which painted by Barium Sulfate capable of absorbing a significant portion of X-ray was used with different thickness and composition. The measurements were recorded at various applied voltages (50 kVp to 120 kVp), and the transmitted and backscattered x-ray was measured using ion chamber. The results showed that the cement shielding painted by Barium Sulfate was very effective in the absorption of incident x-ray up to about 95%, and has the ability to reduce backscattered x-ray radiation up to about 75 % by using fabricated iron steel grid based on a plate composed from cement shielding painted by Barium Sulfate.

Key words: Cement Shielding, Barium Sulfate, X-ray, Protection.

1. Introduction

Radiation awareness and protection have been fundamental responsibilities in diagnostic imaging [1]. One of the most serious effect of radiation is its ability to change in DNA molecules [2]. All ionizing radiation causes a similar damage at a cellular level, but this study will focus on x-ray to make the tests about radiation protection from x-ray. X-ray has enough energy to create ion pairs in matter as well as high penetrating causing diffuse damage throughout the body, such as radiation sickness, and increase incident of cancer rather than burns [3]. Radiation protection is an important topic because of the multiple uses of x-ray in many applications. Therefore, many researchers tried to develop effective methods to protect the human body from the effect of x-ray radiation. Also courses about radiation protection are presented to students in many countries to increase their awareness of these aspects [4].

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The two principles of radiation protection are as low as reasonably achievable (ALARA) and Time, Distance, Shielding [5]. Concrete is one of the main materials used in radiation shielding construction due to its excellent performance on radiation protection [6]. The addition of barium Sulfate (BaSo4) to cement affects the fatigue strength of the material, and the mechanical properties of the presence of BaSO4 in cement warrant its further development toward clinical application [7].

The aim of this study is to investigate the capability of cement shielding with Barium Sulfate in absorption of X-ray and to improve the ability of cement shielding in radiation protection.

2. Materials

The idea of this research is to measure the transmission of x-ray through the mixture of cement shielding which painted by Barium Sulfate in order to make radiation protection from x-ray. The Ion Chamber will receive the photons which transmit through the mixture.

2.1 Shielding

The higher energy of the x-rays needs thicker shielding to prevent the transmission of X-ray photons. In this study the fabricated shielding made by using the mixture of cement with Barium Sulfate.

2.2 Barium sulfate

Barium Sulfate BaSO4 is the main material used in this work to test its ability in radiation absorption in order to make radiation protection by mixing Barium Sulfate with cement material. Barium sulfate does not have any toxic effects on human body or the environment. It is primarily used as a whitening agent and as an insoluble support in industrial applications [8]. In fact, Barium Sulfate has the property of melting in water and it is easy converted to the oxide, carbonate and halides. Production of high pure Barium Sulfate, sulfide or chloride is treated with sulfuric acid or sulfate salts.

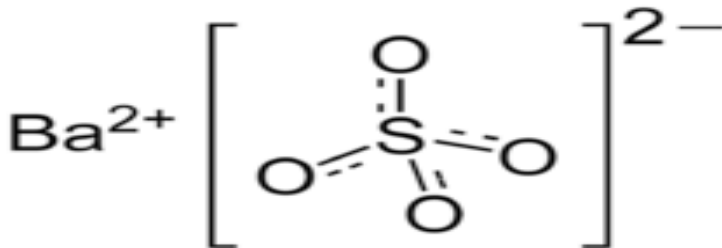
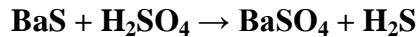


Figure (1): The structure of Barium Sulfate [9]

2.3 Cement

Cement material is a binder made of substance that sets and hardens itself and can bind other materials together. Different types of cement are the result of modifications in the properties of portland cement, this modification affect their physical and chemical carachteristic [10].

3. Methods

In this experiment, blocks of cement are used in order to paint the mixture Barium Sulfate on them. The rate of cement is around 100 gm put in a bowl with little of water inside the bowl till the mixture (cement with water) become semi liquid. Then the mixture is put in the block containers to make the mixture till it becomes dry. The block container has four ribs connected with each other to make a square shape in the middle as shown in figure 2.



Figure (2): Block container



Figure (3): Cement block

The square shape of the blocks of cement is 5×5 cm size with (2mm- 10 mm) thickness after dry out it inside the block containers (Figure 3).

Preparing the mixture (Barium Sulfate – Glue)

The mixture of Barium Sulfate and Glue is mixed well in a plate until the mixture is spread equally on the cement blocks.

4. Results and Discussion

This experiment has investigated the capability of cement shielding painted by Barium Sulfate to make radiation protection from x- ray.

4.1 The effect of cement shielding and Barium Sulfate on Reducing transmitted dose

Figure (4) shows the effect of cement shielding and Barium Sulfate in reducing transmitted x-ray dose measured in unit of milli Gray (mGy), and the difference of transmission X-ray dose between cement shielding and Cement Shielding with Barium Sulfate. The measurement in this part were recorded at x-ray tube current (mA) =320 mA , exposure time (t) =0.1sec, x-ray source to surface distance (SSD) =100 cm, field size=10×10 cm².

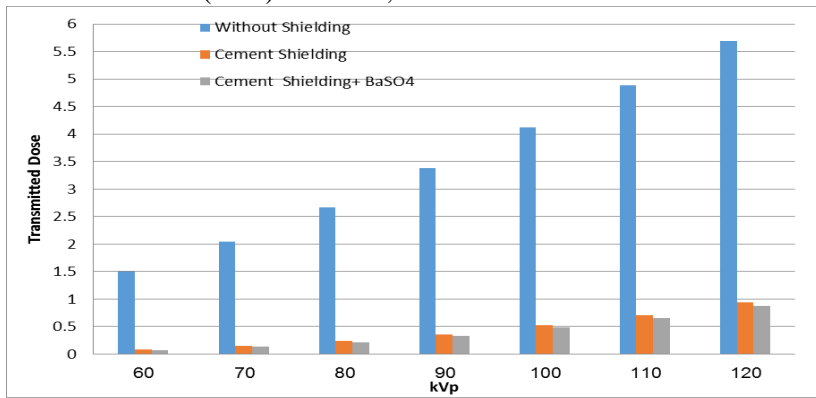


Figure (4): Effect of using cement shielding on transmitted x-ray dose (mGy)

Figure (4) shows the deference between x-ray dose with and without using cement shielding. This difference means that the cement shielding has the ability to reduce transmitted radiation because most of the radiation is absorbed by the cement shielding. Also, this figure shows the effect of painted cement shielding by Barium Sulfate on reducing of transmitted x-ray dose through cement shielding. The results show that cement shielding painted by Barium Sulfate was very effective in the absorption of incident x-ray up to about 95%. In addition, the penetration of x-ray depends on the applied potential voltage of x-ray tube due to the dependence of x-ray photon energy on potential applied voltage (kVp).

4.2 The effect of cement shielding thickness on reducing transmitted dose of x-ray

Different thickness of shielding is used at different applied voltage, mA=320mA, t=0.1sec, SSD=100cm, field size=10×10cm. Figure 5 shows the difference of transmission X-ray dose through cement shielding with Barium Sulfate due to the difference of its thickness. The penetrating of x-ray through cement shielding depends on the applied voltage kVp due to increasing of x-ray photons energy by increasing of kVp.

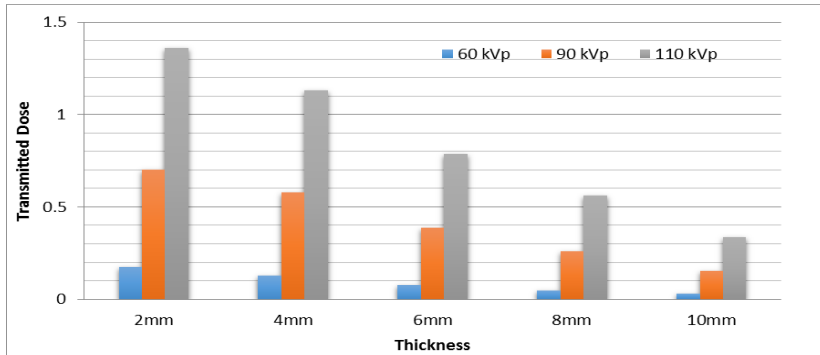


Figure (5): The effect of shielding thickness on transmitted radiation dose (mGy)

This figure shows that the high attenuation of x-ray dose was recorded at 10 mm thickness and the ability of cement shielding in the absorption of x-ray depends on shielding thickness. For each increase of thickness of the cement block there is a significant difference for X-ray attenuate. Figure 5 shows the good protection of cement block because the attenuation of X-ray for the thickness 10 mm of cement shielding is more than 75% to the attenuation of X-ray for the thickness 2 mm.

4.3 The effect of multiple layers of Barium Sulfate on reducing transmitted dose through cement shielding

This section measures the effectiveness of multiple layers of Barium Sulfate on improvement of shielding ability to attenuate radiation. The measurements are collected at mA=320mA , t=0.1sec, SSD=100cm, field size=10×10cm. Figure 6 shows the difference of absorption of x-ray due to the increasing the number of Barium Sulfate layers on cement shielding.

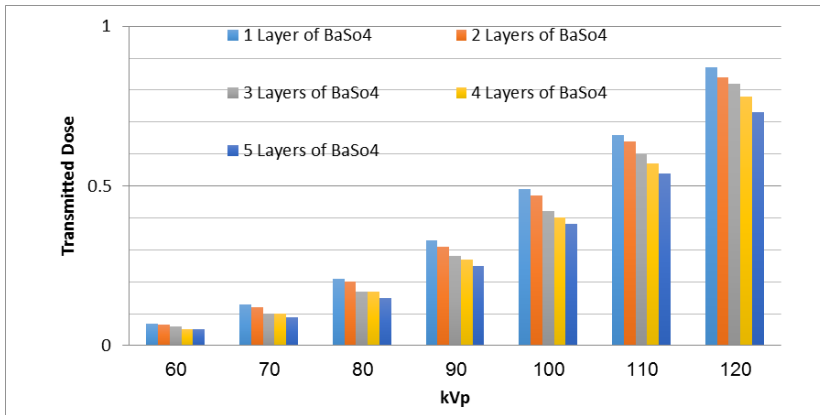
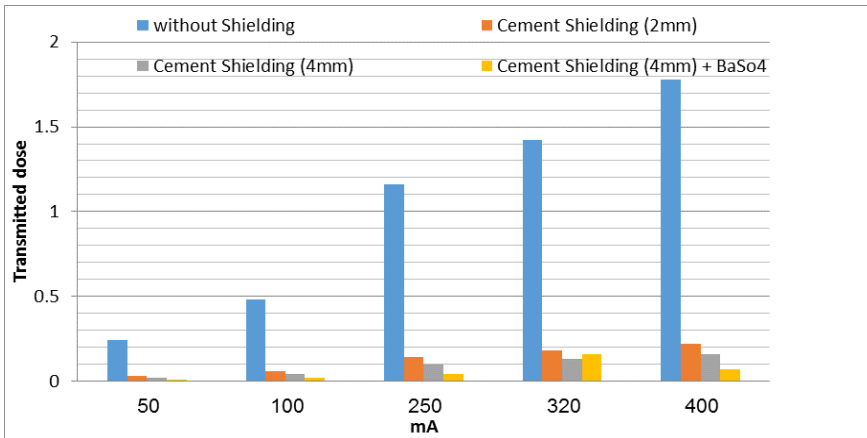


Figure (6): Effect of multiple layers of Barium Sulfate on transmitted dose (mGy)

The cement block painted several times by a mixture of barium sulfate in order to increase radiation protection of the sample. In all kVp readings there is a difference between the values of transmitted x-ray through cement shielding according to the number of layers of Barium Sulfate and the differences of transmitted dose are shown clearly at high applied voltage.

4.4 The effect of Barium Sulfate on reducing transmitted dose of x-ray at different x-ray tube current (mA)

Figure 7 shows the effect of shielding contents and shielding thickness in the reduction of transmitted x-ray at different tube current of x-ray unit. The results were recorded at kVp =60kVp, t=0.1sec, SSD=100cm, field size=10×10cm, one meter distance between x-ray machine source and surface of target material. The penetration of x-ray increases with increase of x-ray tube current. There is a clear relationship between the transmitted radiation dose and x-ray tube current (mA).



Figure(7): Transmitted dose in (mGy) at different x-ray tube current (mA)

Figure 7 shows that there is a clear relationship between the transmitted radiation dose and x-ray tube current (mA) due to the increase in the number of photons which passed through the shielding when the tube current increases. This figure shows that the minimum transmitted radiation dose recorded for cement shielding painted by Barium Sulfate at all kVp readings.

4.5 The effect of Barium Sulfate on reducing transmitted dose of x-ray at different exposure time (t)

In another part of this study, which is concerned with the most common reasons that has an effect on radiation dose. The results were recorded for different exposure time at 10×10 cm² field size, kVp=60kVp, t=0.1sec, SSD=100cm. the penetrating of x-ray photon is proportional with increasing exposure time, so that the transmitted radiation dose is directly affected by exposure time (t).

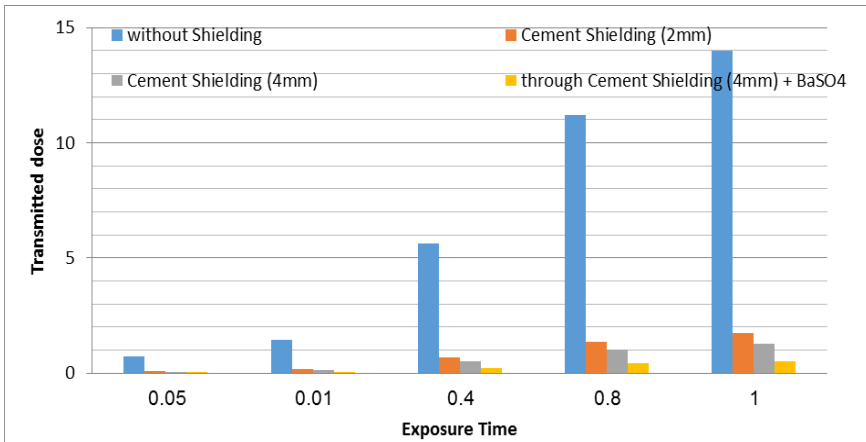


Figure (8): Transmitted dose in (mGy) at different exposure time

The results were recorded for different exposure times ranged from 0.05 sec to 1 sec. Figure 8 shows the relationship between the transmitted radiation dose and exposure time. The ratio of reduction in transmitted radiation increases with reducing x-ray exposure time.

4.6 Backscattered radiation dose for cement plate with Barium Sulfate

This part of the study shows the effect of cement plate painted by Barium Sulfate in reducing back scattered radiation during X-ray exposure in case of putting a cement shielding with Barium Sulfate as a plate under Iron steel grid. The fabricated grid was designed from iron steel constructed of perpendicular parallel strips mounted on a base. All measurements are recorded at x-ray tube current mA=320mA , t=0.1sec, SSD=100cm, field size =10×10cm. the results show that the minimum backscattered radiation dose recorded when the cement plate used under Iron Steel Grid due to the ability of cement plate to absorb incident X-ray.

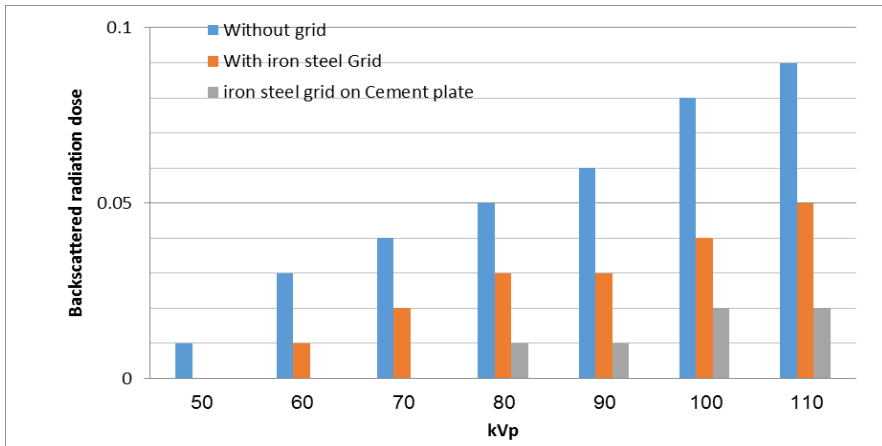


Figure (9): Backscattered radiation dose (mGy) at different applied voltage (kVp)

Figure 9 shows the effectiveness of grid in reducing of backscattered radiation as well as the capability of cement shielding with Barium Sulfate in the attenuation of x-ray due to its ability in reduction of transmitted x-ray and scattered x-ray. The results also show that the minimum backscattered radiation dose recorded when the Iron Steel grid uses with cement shielding plate due to the ability of cement plate in absorbing radiation. Also figure 9 shows that cement Shielding painted by Barium Sulfate has the ability to reduce backscattered x-ray radiation up to about 75 % by using fabricated iron steel grid based on plate composed from cement shielding painted by Barium Sulfate.

5. Conclusion

The results show that the ability of cement shielding on attenuation and absorption of x-ray depends on a number of factors such as the components of shielding and exposure parameters (kVp, mA, exposure time). Cement shielding which is painted by Barium Sulfate has a high effective on the absorption of x-ray and the reduction of Backscattered radiation. The capability of cement shielding painted by Barium Sulfate increases with the increase in the number of Barium Sulfate layers on shielding, furthermore the dose of penetrated X-ray through cement shielding depends on the photon energy, tube current, and exposure time.

6. References

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