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Manual Processing of X-Ray and Gamma-Ray Films – Preliminary Study

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ABSTRACT

Radiographic testing (RT) is a non- destructive technique (NDT) method which uses either X-rays or Gamma rays to examine the internal structure of manufactured components identifying any flaws or defects. Advantages of RT include it can be used with most materials, provides a permanent image record of the test, reveals internal nature of materials, discloses fabrication errors and often indicates necessary corrective action and reveals structural discontinuities and assembly errors. Both radiation sources have different properties in term of energy level, intensity and wavelength. There are several issues based on the quality of the film such as poor development, film fogging and poor contrast. Due to that, radiographic film processing is an important step to produce visible image. The objective of this study is to study a radiographic film using manual processing. Both X-ray and Gamma- ray film will undergo six steps which are developing, stop bath, fixing, washing, wetting agent and drying. After drying, both films will undergo viewing process using Densitometer. The identification in the radiographic film was identified based on the instruction number, personal number, specimen number and date of testing. The results show a different quality of visible image formed for both X-ray and Gamma- Ray.

1. Introduction

Radiation is the process by which energy is released from a source and then travels through a medium until it is absorbed by matter. There are two forms of radiation: non-ionizing radiation and ionising radiation. It is frequently utilised for non-ionizing radiation in microwave ovens, cellular cellphones, television stations, and other devices. Its property of not carrying enough energy to ionise atoms or molecules allows it to be employed for home purposes. X-rays are released by activities outside the nucleus, whereas gamma rays are produced within the nucleus [1]. They are also less energetic and hence less penetrating than gamma rays.

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To maintain maximum quality in operation, create a radiograph of a sample that shows any changes in thickness, flaws (internal and exterior), and assembly details. With the exception of double-wall signal imaging methods utilised on certain pipe, RT is typically suited for testing welded connections that can be accessible from both sides [2]. While this is a time-consuming and costly NDT approach, it is a reliable way of detecting porosity, inclusions, fractures, and voids in weld interiors. RT employs X-rays or gamma radiation. An X-ray tube generates X-rays, whereas a radioactive isotope generates gamma rays [3]. The radiographic film detects and measures the varied amounts of radiation received throughout the full surface of the film. This film is then processed in a dark room, and the various degrees of radiation received by the film are imaged by a display of varying degrees of black and white; this is referred to as the film density, and it is examined on a densitometer.

The amount of radiation received by the film via that particular plane of the material is affected by material discontinuities. Trained inspectors can evaluate the photos and document the location and kind of flaw in the material. Radiography may be employed on a wide range of materials and product shapes, including welds, castings, and composites [4].

Radiographic testing creates a permanent record in the form of a radiograph as well as a very sensitive image of the internal structure of the material [5]. The quantity of energy absorbed by an item is proportional to its thickness and density. The radiography film is exposed due to energy that is not absorbed by the object. When the film is processed, these regions will be dark. Less energy-exposed areas of the film stay lighter. As a result, sections of the item where the thickness has been modified by discontinuities such as porosity or cracks will appear on the film as black outlines. Low density inclusions, such as slag, appear on the film as black regions, but high-density inclusions, such as tungsten, appear as light patches. Viewing the weld form and fluctuations in the density of the treated film detects all discontinuities [6]. If people are properly taught, this permanent film record of weld quality is rather simple to understand.

Because inaccurate readings may be expensive and significantly interrupt production, and because invisible X-ray and gamma radiation can be deadly, only competent individuals should perform radiography and radiographic interpretation. In radiography, the image quality indicator (IQI) is based on a reference code or standard [7]. IQI radiography ensures that adequate radiography film quality is attained. A radiography film's sensitivity is the smallest size of discontinuity that can be detected in that radiography film. IQI is a collection of standard wires with standard diameters and hole types [8]. In that scenario, standard thickness plates with standard diameter holes will be used. The contract, component, weld, or part number is the purpose for identification for traceability. Manufacturer's symbol/name, date of radiograph, voltage source utilised, project number, and method or instruction number are all examples of identification. Furthermore, a location marker must be permanently placed on a sample and visible as radiological pictures.

The thicker the material, the more energy it can absorb, because the energy has to pass through a larger volume. This means it has a greater potential to interact with the material's atoms or molecules [9]. While, denser materials have more atoms or molecules per unit volume. As a result, there is a higher chance of energy interacting with these particles. A denser material will usually absorb more energy than a less dense material of the same thickness. In radiation physics, the attenuation of radiation as it passes through a material is often described by the Beer-Lambert Law, which relates the intensity of radiation after passing through a material to the material's thickness and density [10].

In traditional radiography, a special type of film is used to capture the X-ray image. The film contains light-sensitive chemicals (silver halides) that react when exposed to radiation, creating a latent image that can be developed later to produce a visible picture. In modern digital radiography, instead of film, electronic sensors are used to capture the transmitted radiation. These sensors convert the energy into a digital image directly [11]. The film or detector is exposed by the X-rays that pass through the object. This exposure is what forms the image, and the contrast between different tissues in the object (such as bones vs. soft tissues) results in the distinct features seen in the final radiograph. The varying levels of exposure to the film produce different shades of light and dark, creating an image with contrast [12,13].

The primary function of the location marker in radiographic testing is to aid in identifying specific points or features on the sample, providing a clear and permanent reference for interpreting the radiographic image [14,15]. In radiographic NDT, the location marker is a critical tool that ensures accurate, repeatable, and well-documented inspections. By permanently placing a marker on the sample and ensuring it is visible on radiographic images, inspectors can precisely identify the areas of interest, track changes over time, and maintain the integrity and consistency of the testing process [16,17].

During NDT, the objectives are to identify the region of interest and the area of a sample covered by a particular radiograph [18]. The darkroom is the starting point for manual processing. The darkroom should be centrally positioned, next to the reading room and a suitable distance from the exposure area. Film should be stored in a light, tight chamber, which is often a metal bin used to store and protect the film. Loading and unloading the film should take place in a dry, dust-free area near the film bin. The wet side of the film should be treated separately. This approach protects the film from any water or chemicals that may be present on the wet side's surface. As previously stated, radiographic film is made up of a translucent, blue-tinted base that is covered on both sides with an emulsion. The emulsion is made of gelatin that contains small, radiation-sensitive silver halide crystals like silver bromide and silver chloride. Some Br- ions are freed and caught by the Ag+ ions when x-rays, gamma rays, or light rays impact the crystals or grains. The radiograph is considered to have a latent (hidden) image in this condition because the change in the grains is nearly invisible, but the exposed grains are now more sensitive to developer response.

2. Methodology

The D7 film was loading in the cassette. Prior to that, the surface of lead screen was checked either it is having water, not dented, not dirty and no scretched. The film was checked in white light ambient. The plate and tube steel that welded in the center was used in this study. The identification such as location marker, Image quality indicator (IQI), instruction number, name of service provider, name of personal number, specimen number and date were arranged using the provided alphabet. Before the X-ray and Gamma-ray film procedure, the survey meter and pen dosimeter were checked for availability and warning sign was placed. The resulted film from X-ray and Gamma- ray exposure will undergo film processing.

The films undergo the unloading film process after it is exposed to the X-ray and Gamma-ray. In white light mode, the temperature of the developer tank in running water condition was checked for 2 minutes by immersing the thermometer. Then switch off the white light and switch on the safe light. Unloaded the film in the film hanger. The temperature of the developer is 24^{o}C. The film was immersed for 5 minutes in the developer tank. Then followed by a stop bath, fixing, washing, wetting agent and lastly is drying in the dryer. The prepared film hanger was checked and was dry in dryer cabinet.

3. Results

Radiation interaction during sample transmission is affected by radiation energy, atomic number, density, and thickness [19]. When radiation strikes a film after passing through the test item, all information about the object's interior state is conveyed to the radiography film. When the film has been processed, visible images appear. Both films undergo manual processing. The radiography schematic arrangement was shown in Figure 1.

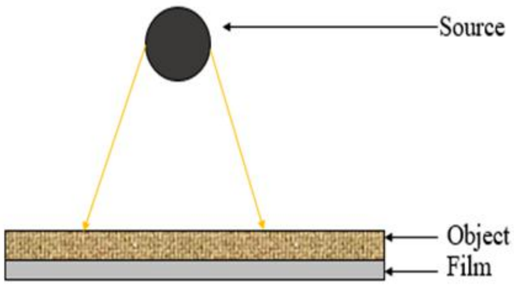


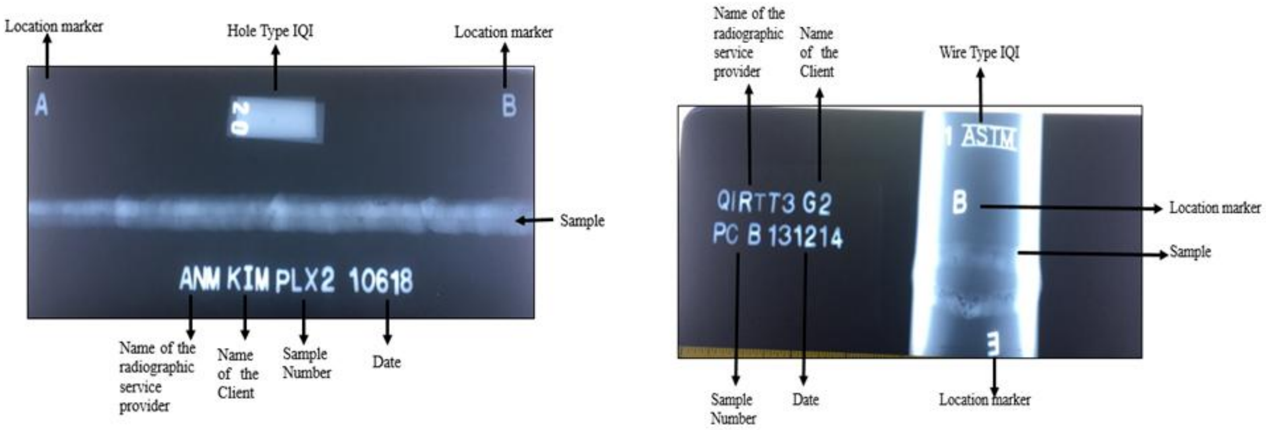
Fig. 1. Radiography set up

The radiographic X-ray film was shown in Figure 2 where the (a) steel plate (b) steel tube sample clearly shown an identification. As the film is treated, it is exposed to a variety of chemical solutions for varying lengths of time. Film processing refers to the activities required to convert the latent picture on the film into a permanent, visible image, which typically include developing, fixing, washing, and drying the film. The function of each part was brief in the Table 1.

Table 1
Function of each part in film manual processing

Developer	Stop bath	Fixer	Wash	Wetting Agent	Dryer
• Alkaline (pH 11)	• Acetic acid	• Acetic acid	• Running water	• Remove air bubble or dirt	• Drying film
• Developing agent	• Neutralizes	• Preservatives	• Wash out residual fixer		
• Accelerator	• Stop development action	• Hardener			
• Preservative		• Buffer			
• Restrainer		• Neutralizes			
• Replenishment		• Permanently fix the image			
• Reacts or developed the exposed grains (latent image)		• Dissolves and removes all unexposed grains			
• Depend on the development time, chemical strength and temperature		• Harden the emulsion gelatin to prevent scratch			
• Developer exhausted rapidly					

Film processing consists of the five stages. The process begins with developer, in which the developing agent gives away electrons in order to convert the silver halide grains to metallic silver [20]. Grains exposed to radiation develop faster, but given enough time, the developer will transform all of the silver ions into silver metal. To convert exposed grains to pure silver while leaving unexposed grains as silver halide crystals, proper temperature control is required. The second method is a stop bath, which simply stops the development process by diluting and washing away the developer with water. The fixing bath removes unexposed silver halide crystals in the third step. Only silver halide crystals are dissolved by the fixer, leaving the silver metal behind. The fourth step is washing, which involves washing the film with water to remove all of the processing chemicals. Finally, drying occurs when the film is ready for viewing.



(a) (b)

Fig. 2. Radiographic (a) X-ray film (b) Gamma film

4. Conclusions

Based on the results obtained, the radiographic film exposed to X-ray and Gamma ray can produced a good image by using manual processing. The handing process must be control and fit the standard technique provided.

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