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Abstract Book

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A Comparison of Defect Size and Film Quality Obtained from Film Digitizer Image and Digital Image Radiographs

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Abstract

Digital radiographic testing is an acceptable premature nondestructive testing technique. Its performance and limitation comparing to the old technique are still not widely well known. In this paper, authors conducted the study on the comparison of the accuracy of the defect size measurement and film quality received from film and digital radiograph techniques by testing in specimens and known size sample defect. Initially, the three specimens, made from carbon steel grade ASTM A36 size 12x150x200 mm, were built three types of internal defect; which are longitudinal cracking, lack of fusion, and porosity. For the known size sample defect, it was machined various geometrical size for comparing the accuracy of the measuring defect size to the real size in both film and digital images. To compare the image quality by considering at smallest detectable wire and the three defect images, the authors used Image Quality Indicator (IQI) of wire type 10/16 FE EN BS EN-462-1-1994. The radiographic films were produced by X-ray and gamma ray using Kodak AA400 size 3.5x8 inches, while the digital images were produced by image plate brand of Fuji type ST-VI. Its resolution is 100 micrometers. During the tests, a radiator GE brand model MF3 was implemented. The energy applied is varied from 120 to 220 kV and the current from 1.2 to 3.0 mA. The intensity of Iridium 192 gamma ray is in the range of 24-25 Curie. Under conditions mentioned above. The results showed that the deviation of the defect size measurement comparing to the real size received from the digital image radiographs is below than that of the film digitizer radiographs, whereas the quality of film digitizer radiographs is higher in comparison. Theories, analysis and the limitations are explained in details in this paper.

Keywords: Nondestructive testing, Film image, Digital Image and Sample Defect Comparison

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A comparison of defect size and film quality obtained from Film digitized image and Digital image radiographs

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ABSTRACT

Digital radiographic testing is an acceptable premature nondestructive examination technique. Its performance and limitation comparing to the old technique are still not widely well known. In this paper conducted the study on the comparison of the accuracy of the defect size measurement and film quality obtained from film and digital radiograph techniques by testing in specimens and known size sample defect. Initially, one specimen was built with three types of internal defect; which are longitudinal cracking, lack of fusion, and porosity. For the known size sample defect, it was machined various geometrical size for comparing the accuracy of the measuring defect size to the real size in both film and digital images. To compare the image quality by considering at smallest detectable wire and the three defect images. In this research used Image Quality Indicator (IQI) of wire type 10/16 FE EN BS EN-462-1-1994. The radiographic films were produced by X-ray and gamma ray using Kodak AA400 size 3.5x8 inches, while the digital images were produced by Fuji image plate type ST-VI with 100 micrometers resolution. During the tests, a radiator GE model MF3 was implemented. The applied energy is varied from 120 to 220 kV and the current from 1.2 to 3.0 mA. The intensity of Iridium 192 gamma ray is in the range of 24-25 Curie. Under the mentioned conditions, the results showed that the deviation of the defect size measurement comparing to the real size obtained from the digital image radiographs is below than that of the film digitized, whereas the quality of film digitizer radiographs is higher in comparison.

Keywords: Film digitized image, Digital image radiographs and Sample Defect Comparison

1. INTRODUCTION

At present, the digital radiograph has developing for replacement of the film industrial radiograph. It is firstly developed from medical industrial by using the image plate for substitute radiography film. However, the size and image quality obtained by the digital radiograph and film radiograph are still under arguing on the accuracy in the sizing and image quality of both techniques.

In the period of film digitized, defect measurement and image quality by computer software has been researched how to achieve film digitized image quality and defect grading. Recently, there are a number of researches, for examples, film replacement by digital techniques applied to weld inspection by Brazil^[10], effect of energy and imaging filter on corrosion measurement for a pipe by using digital computed radiography by Thailand scholar^[2] and Chaoming SUN from China also researched a defect grading method for digital radiographic image^[7]. The defect measurement and quality obtained from radiograph image was not included in the period study. Also there are factors that were not considered, which are the film radiograph image, Iridium 192 gamma ray usage, IQI's (Image Quality Indicator), including deviation of the X-ray radiation. Therefore, the purpose of this research is to study the size measurement and image quality obtained from film and digital radiograph with computed program

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using standard sample defect comparison, IQI, and fault acknowledge, energies varied from 120 to 220 kV and the intensity of Iridium 192 gamma ray is in the range of 24-25 Curie, to find the factors that effect on the accuracy in the testing.

In this paper, the result has shown the comparison of a size measurement and quality obtained from digital image radiograph and film digitized image radiograph which are based on theory, experiment set up procedure, and equipment. The expected benefit from this research is to apply the radiography image for effectively identify the defects. Finally, the proper techniques then can be alternatively for the Nondestructive Examination applicable in industries.

2. THEORY

Experiment of a comparison defect size and film quality obtained from conventional film radiograph and digital image radiograph, this method cannot be directly performed with the conventional film. Therefore, it has to be converted by digital camera into digital file. After that, the digitized process is conducted by executable eFilm 3.0 workstation software. Then, it is called "Film Digitized Image". The theories to explain this process are described as below.

2.1 Radiographic testing^[1]

The radiographic testing is applied for both film image and digital image by the emission of electromagnetic radiation with a high frequency from the radiation source through the specimen, which made of different of radiation absorbance capacity material. The energy of the radiation go through work some more, and react with substances in the film or image plate over another part. When the shadow is generated by the radiograph, it can be seen that the intensity of the image area will be darker than the other parts. However, radiography can be interpreted of the shadow of the specimen that appeared on the film image or digital image.

2.1.1 Film radiographic

Technology in film radiography is the common method that has been used for a long time, which it is required in the film processing operation. The film images require the chemical and drying time consuming to create the image which certainly we cannot overlook these sequences or procedures. The data management and reporting results with film interpretation is also difficult to accumulate.

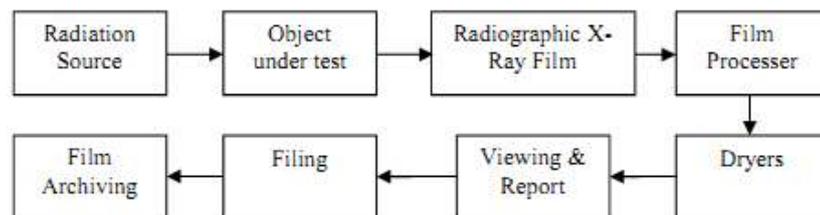


Figure 1 - Processing flow chart of Basic conventional film radiographic^[2]

2.1.2 Film digitized image

The flowchart below describes the process of film digitizing. Firstly, the film images are obtained from Iridium 192 gamma ray and X-ray radiation. They are process into jpeg file by digital camera with resolution 10 million pixels. After that, it was digitized image process by eFilm 3.0 workstation program into Dicom file. The executable ISee analysis software was used for viewing and measuring.

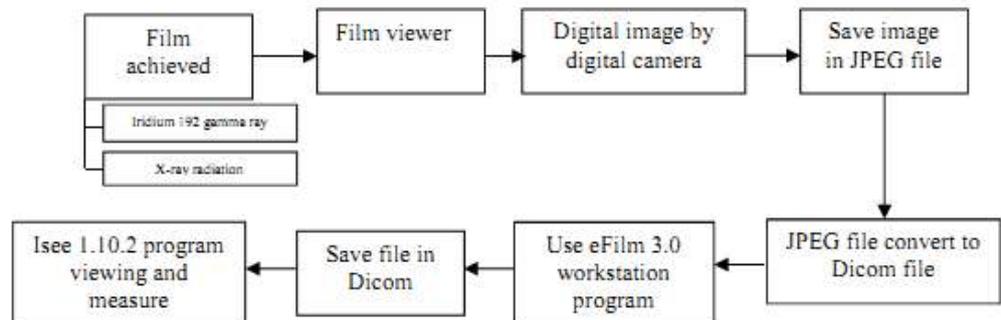


Figure 2 - Processing flow chart of basic conventional digital image radiographic

2.1.3 Digital image radiographic^[2]

Technology in digital image radiography is using an image plate instead of the film. The radiation imaging system with digital image radiographic technology allows a quick test more than ever. The data management, monitoring and reporting of the results is managed by the computer software.

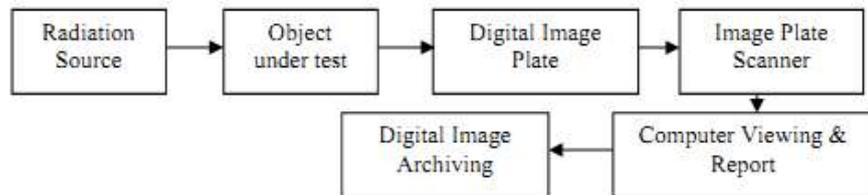


Figure 3 - Processing flow chart of basic conventional digital image radiographic

2.2 Image quality requirements

The image quality requirements for the samples is based on standards visible number of the image quality indicator (IQI) EN-462-1 10/16 FE EN BS EN-462-1 1994 ^[8] always on the source side. The executable ISee analysis software was used.

Specimen Thickness (mm)	Contrast-Essential Wire (DIN) EN-462-1	
	Normal wire diameter (mm)	IQI Value
10<t≤15	0.25	W12

Table 1 - Radiographic quality requirements for the images

- 2.2.1 The quality requirement of film image radiography on the obtained image, it is necessary to determine the radiographic sensitivity through the use of IQIs (Image Quality Indicators). However, the sensitivity to contrast of the IQI as well as the value of density is measured by the value of the standard should be in the range of 2.0 to 4.0 included geometric unsharpness of the radiograph shall determine in the quality of the film images ^[16].
- 2.2.2 The quality requirement of digital image radiograph on the obtained image, it is necessary to determine the radiographic sensitivity through the use of IQIs (Image Quality Indicators). Nevertheless, two additional parameters appear: Basic Spatial Resolution (SR_b) and Normalized Signal to Noise Ratio (SNR_N). The basic spatial resolution of a digital

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radiography system corresponds to the effective pixel size of the image; however the signal to noise ratio (SNR) may be described as the linear proportion between the average value of the signal intensity and the signal noise standard deviation in this intensity^[10]. However, this research does not consider those factors for comparison the quality of film digitized image and digital image. The experiment is considered only the smallest detectable wire IQIs.

- 2.2.3 The interpretation and evaluation of film image obtained from film digitized image and digital image as to fault detectability were considered approved when it shows the entire fault acknowledged in the film.

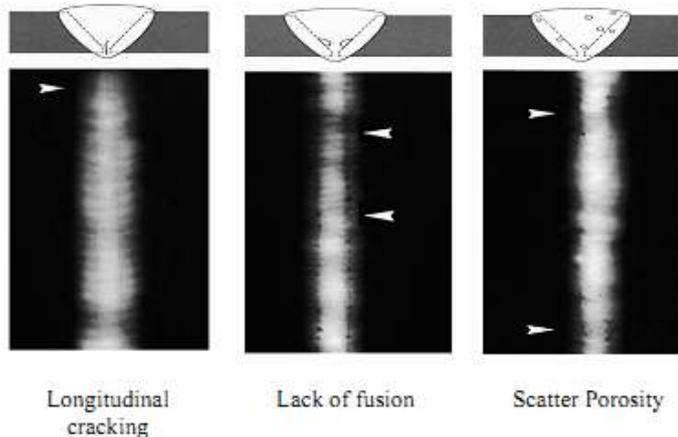


Figure 4 - The example film radiographic interpret and evaluation weld defect

2.3 Welding discontinuities and Sample defect comparison

- 2.3.1 The welding discontinuities are built with three types of internal defect; which are longitudinal cracking, lack of fusion, and porosity.
- **Porosity**, this occurs when gases are trapped in the solidifying weld metal. These may arise from damp consumables or metal or, from dirt, particularly oil or grease, on the metal in the vicinity of the weld.
 - **Lack of fusion**, a weld discontinuity in which fusion did not occur between weld metal and fusion faces or adjoining weld beads.
 - **Cracking**, this can occur due just to thermal shrinkage or due to a combination of strain accompanying phase change and thermal shrinkage. In the case of welded stiff frames, a combination of poor design and inappropriate procedure may result in high residual stresses and cracking.

The three type of defect will cause loss of cross-sectional area and reduced strength.

- 2.3.2 The standard sample defect comparison is designed for interpret and evaluation in image obtained from film digitized image and digital image. The standard sample defect is designed and made with copper material with a size 0.8mmx20mmx40mm in accordance with standard of GB/T 3233-2005^[5] and JB/T4730-2008^[6], a 10mmx25mm rectangular size



and circular through hole are made on the sample the hole size $\varnothing 0.3$, $\varnothing 0.5$, $\varnothing 1.0$, $\varnothing 2.0$, $\varnothing 3.0$, $\varnothing 4.0$, $\varnothing 6.0$, and $\varnothing 8.0$ [7] respectively.

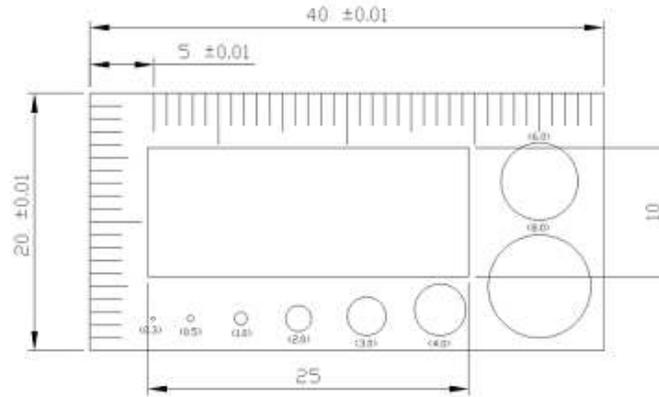


Figure 5 - Sample defect comparison standard

2.4 Size measurements of sample defect comparison

The size measurement is performed by using the executable ISee analysis software as a tool for measuring on sample defect images obtained from film digitized image and digital image radiographs. The size of pixel is calibrated by laying the image over an object of known size, then marking the object in the profiler window. The program will show the window with the gray value level after laying over the image and show the pixels amount of the length that has been determined. Then the known size shall be entered in the window, the program will calibration from the pixels into millimeters.



Figure 6 - Example size measurement on sample defect comparison

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3. EXPERIMENT SET UP

The purpose of the experiment is to compare the defect size and film quality obtained from film digitized image and digital image radiograph. Then the experiment is designed as below details.

3.1 Setting of Radiography testing

Initially, the experiment has been conducted with specimen was designed and prepared with carbon steel material grade ASTM A36^[4]. The size of test specimen is 12mmx150mmx 200 mm with three (3) types of flaw which are longitudinal cracking, lack of fusion, and porosity. The performed conventional film image is Kodak AA400^[15] size 3.5 inch x 8.5inch cassette with lead screen thickness size 0.125mm on the both sides. The image plate Fuji^[12] ST-VI image with resolution of 100 micrometers is used.

Moreover, the intensity of iridium 192 gamma ray performed is in the range 24-25 curie radiation. The radiation source to film is set at distance (SFD) 500 mm. Moreover, the radiation source, X-ray tube with 3 mm focus size, X-ray equipment GE^[11] model MF3, is applied to provide the energy to the maximum 300 kV max. 4.5 mA, which the energy level was selected from the exposure chart, is divided into 6 ranges (Table 2). The radiation source to film is set at distance (SFD) 550 mm that applied for film and image plate.

Furthermore, the photo of conventional film radiographs achieved the digitizing process were taken on the viewer with digital camera brand Nikon model N1 then saved into the JPEG file. After that, the film digitized by computer program eFlim workstation version 3.4.0^[13] is used as a tool to convert the JPEG file to a Dicom file

Item	Radiation Level (kV)	Current Level (mA)	Time of Irradiation (min)
1	120	3.0	7.4
2	140	3.0	1.8
3	160	2.0	1.2
4	180	2.2	0.6
5	200	1.2	0.6
6	220	1.2	0.6

Table 2 – Radiation level of the x-ray radiation energy

3.2 Size Measurement

Size measurement of specimen using Isee program version 1.10.2 is calibrating the width of standard sample defect comparison which was designed in section 2.3.2 before measuring circular and rectangular image obtained from radiograph.



Figure 7 – Method for size measurement



3.3 Quality Measurement

Quality measurement is done by visible of smallest detectable wire IQIs (Image Quality Indicators) and three defect image on the image radiograph obtained from film digitized radiograph and digital image radiograph.



Figure 8 – Quality measurement

4. RESULT/DISCUSSION

From these experiments had conducted experiments to compare the defect size and quality obtained from the film digitized image and digital image radiographs. Firstly, it was designed based on the specimen as in section 2.3.1, and the standard sample defect comparison designed in section 2.3.2. Therefore, It had compared the defect size and quality obtained from the film digitized image and digital image radiographs. Finally, in this research has shown the result of comparison of a size measurement and quality obtained from digital radiograph image and film digitized radiograph image which is based on radiation energy, IQI and standard sample defect comparison.

4.1 Comparison of size measurement obtained from X-ray and gamma ray

The size of sample defect comparison is measured from the film digitized images which have been in X-ray process with energy applied in between 120-220 kV, current 1.2-3.0 mA and Ir192 gamma ray with the intensity of the radiation in the range 24-25 curie. The computed program Isee version 1.10.2^[14] is applied as a tool to measurement the size on the sample defect comparison. Additionally, films digitized were interpreted and evaluated including measurement by two experienced personal who have qualified with certificate RT Level II in accordance with ASNT-TC-1A^[9] and CSWIP RI (TWI)^[17]. The results were shown in average on table 3.

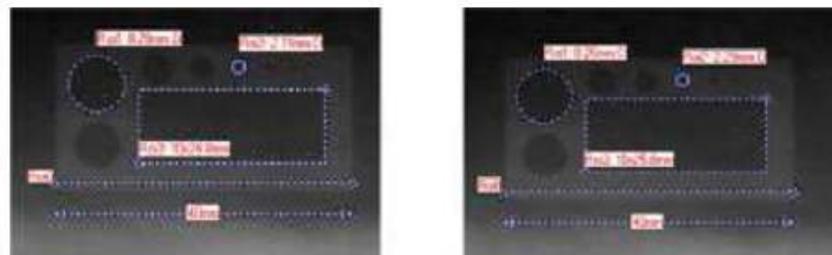


Figure 9 - Example size measurement on sample defect comparison in Ir 192 gamma ray film images

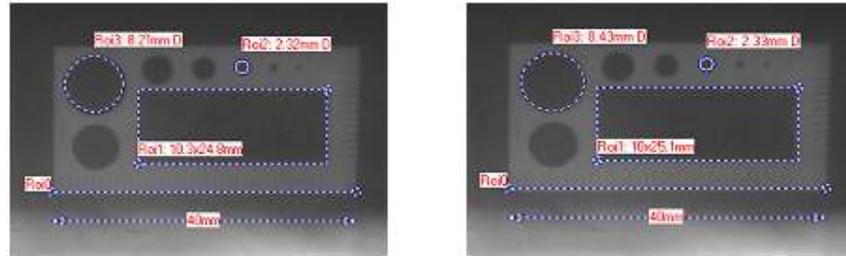


Figure 10 - Example size measurement on sample defect comparison in 180 kV film images

Variable (kV)	Sample defect size comparison films digitized image			
	Ø 8.010	Deviation	Ø 2.010	Deviation
120kV-3.0mA.min	8.190	0.180	2.170	0.160
140kV-3.0mA.min	8.380	0.370	2.190	0.180
160kV-2.2mA.min	8.375	0.365	2.205	0.195
180kV-2.0mA.min	8.320	0.310	2.325	0.315
200kV-1.2mA.min	8.280	0.270	2.275	0.265
220kV-1.2mA.min	8.375	0.365	2.270	0.260
Ir 192 gamma ray 24-25 curie	8.270	0.260	2.200	0.190

Table 3 - Films digitized image radiograph in X-Ray and Gamma Ray size comparison

Table 3 Shows the sample defect size measurement that obtained from film digitized image radiographs used the X-Ray and Iridium 192 gamma ray that the deviation the defect size compared as designed to the real size obtained from X-Ray energies level 120kV and 140 kV are better that gamma ray whereas the energies level between 160 kV and 220 kV below than gamma ray.

4.2 Comparison of size measurement Obtained from Film digitized and Digital image

The size of sample defect comparison is measured from the film digitized images which have been in X-ray process with energy applied in between 120-220 kV, current 1.2-3.0 mA. The DIR system is composed by image plate brand Fuji ST-VI image resolution of 100 micrometers size 14inchx17inch with a laser scanner Fuji Dynamix HR then recorded the occurred electrical signals via computer using Fuji DynaView which is the Dicom file. Then computer program Isee version 1.10.2 is applied as a tool to measurement the size on the sample defect comparison. Additionally, films digitized were interpreted and evaluated including measurement by two experienced personal who have qualified with certificate RT Level II in accordance with ASNT-TC-1A and CSWIP RI (TWI). The results were shown in average on table 4.

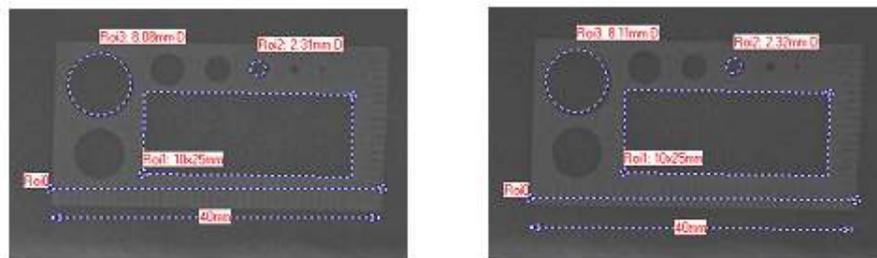


Figure 11 - Example size measurement on sample defect comparison in 180 kV digital images

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Variable (kV)	Sample defect size comparison			
	films digitized image			
	Ø 8.010	Deviation	Ø 2.010	Deviation
120kV-3.0mA.min	8.190	0.180	2.170	0.160
140kV-3.0mA.min	8.380	0.370	2.190	0.180
160kV-2.2mA.min	8.375	0.365	2.205	0.195
180kV-2.0mA.min	8.320	0.310	2.325	0.315
200kV-1.2mA.min	8.280	0.270	2.275	0.265
220kV-1.2mA.min	8.375	0.365	2.270	0.260

Variable (kV)	Sample defect size comparison			
	digital image radiographs			
	Ø 8.010	Deviation	Ø 2.010	Deviation
120kV-3.0mA.min	8.160	0.150	2.330	0.320
140kV-3.0mA.min	8.480	0.470	2.315	0.305
160kV-2.2mA.min	8.305	0.295	2.125	0.115
180kV-2.0mA.min	8.095	0.085	2.135	0.125
200kV-1.2mA.min	8.305	0.295	2.125	0.115
220kV-1.2mA.min	8.305	0.295	2.330	0.320

Table 4 - Films digitized image and digital image radiograph size comparison

Table 4 shows the sample defect size measurement obtained from film digitized image and digital image radiographs. Also it shows a comparison to the defect size accomplished by the X-ray, DIR in radiation divided 6 range. The results as calculation have showed that, the deviation of the defect size compared as designed to the real size obtained from the DIR is below than that of the film digitized. However that result base on the calculation of data from the interpreter. As the result, it can be alternative of energy level of both techniques to be applied to the suitability of the work.

4.3 Film digitized images and Digital images quality requirements

For the image quality requirements, the image quality indicator wire 10/16 FE EN BS EN426-1 1994 were used for the measuring of quality requirement based on standards sensitivity to contrast values of the image quality indicator shown on the film digitized image and digital image. Moreover, the results related to the images obtained by the gamma ray, X-ray and computed radiograph as to fault detectability.

Variable (kV)	Sensitivity to contrast	
	films digitized image	digital image radiographs
120kV-3.0mA.min	W13	W13
140kV-3.0mA.min	W13	W13
160kV-2.2mA.min	W14	W13
180kV-2.0mA.min	W14	W13
200kV-1.2mA.min	W14	W13
220kV-1.2mA.min	W13	W13
Ir 192 gamma ray 24-25 curie	W12	N/A

Table 5 - Films digitized image and digital image radiographs sensitivity comparison

Table 5 shows the sensitivity to contrast values obtained with the use of film digitized image and digital image radiographs. Also it shows a comparison to the sensitivity accomplished by the X-ray, DIR in radiation

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divided 6 range and Ir192 gamma ray. The results have showed that, the quality obtained from film digitized images is higher than DIR in comparison however the quality of gamma ray is below than X-Ray and DIR.

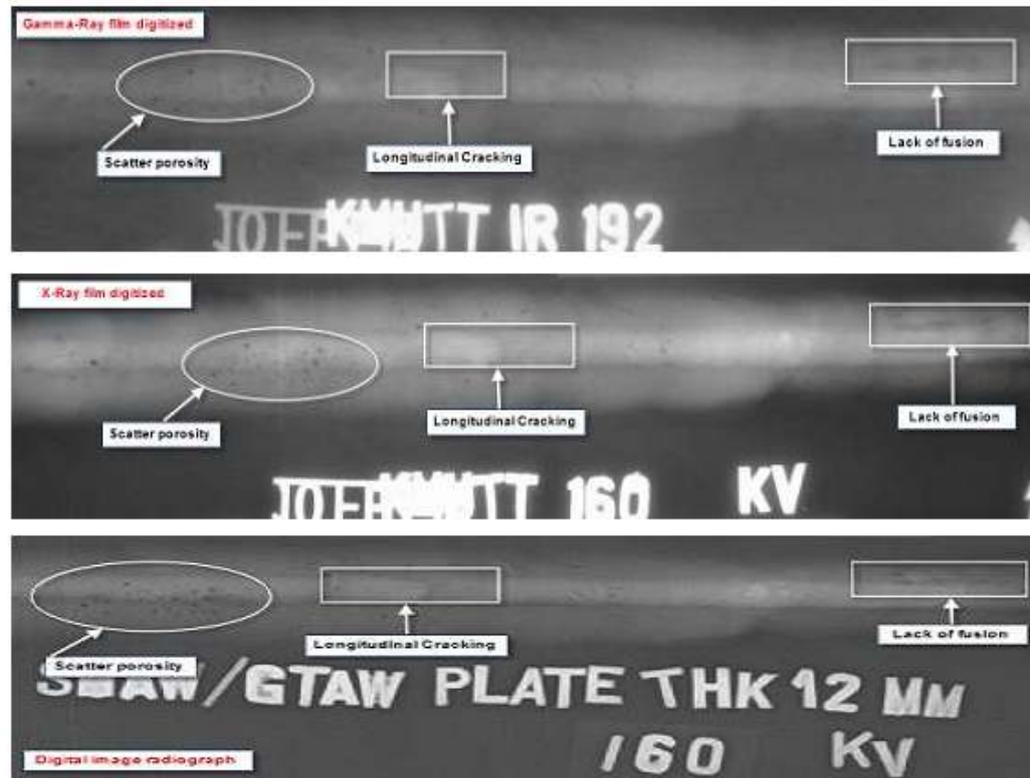


Figure 12 - Films digitized image and digital image radiographs fault acknowledge comparison

Figure 12 shows the result related to the comparison between the image obtained by film digitized and DIR as to the fault detectability. The digital images were considered approved only when it showed all the fault acknowledged in the film. The comparison was made between the image obtained with the Ir192 gamma ray, X-ray and DIR system. The results have showed that, the fault acknowledge was shown as built in the specimen as used in all film radiography system.

5. CONCLUSION

Under this condition, the comparison of the standard sample defect comparison and quality image obtained from film digitized image performed by X-ray energy level 120 kV and 140 kV are better than film digitized image performed by Iridium 192 gamma ray whereas X-ray energy level between 160 kV and 220 kV below than gamma ray. In addition, the quality of film digitized image conducted by X-ray radiograph higher than gamma ray.

Based on these results, the size measurement in image radiograph obtained from film digitized image compared to digital image radiograph shows that the deviation of the defect size compared as designed to the real size obtained from the DIR is below than that of the film digitized.

For the image quality measurement, the results showed that, the visible smallest detectable wire of IQIs (Image Quality Indicator) obtained from film digitized image is higher than digital image radiograph in compared.

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Moreover, the image radiograph obtained by all three techniques showed that the fault detectability were presented the fault acknowledge as built in the specimen as used in section 2.3.1.

However, the results from the experiment are based on the theory, equipment, and energy level, including the equipment in laboratory.

Finally, it was observed that the radiographies obtained with the use of industrial films are still much better, in terms of resolution and visual contrast of the image, than those obtained with digital image radiograph. However, the new technique of digital image radiograph needs further improvement to be an alternative of Non Destructive Examination (NDE) applicable in industries.

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