

CONTRAST GRADIENT DETERMINATION IN DIGITAL RADIOGRAPHY TO OPTIMIZE THE CAPABILITY IN DEFECT DETECTION

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1. Abstract

Digital radiography is a growing technique in x-ray examinations. The field of application is highly promising. The present work has the scope to study the main parameters that affect the quality of image in terms of contrast and definitions to establish the range in which the contrast reach the highest value.

A number of tests has been carried out on stepped wedge calibrated exposed at different level of energy and related time. The range of thickness involved has been between 5mm and 20mm. The steps change value has been between 0.2mm and 1mm.

Two fundamental diagrams have been traced after the experimental tests;
grey level/ relative exposure relation and contrast gradient/ grey level relation.

Another important consideration has been raised during the test; few cents of millimetres in wire diameter can cause a level of sensitivity more than 2% and consequently not accepted by the code.

This change in our opinion has not an effective impacts on the POD of type of defects like, lack of penetration, porosity, cracks, slag inclusion.

We propose in this case a tolerance of wire sensitivity up to 2.5- 3 %.

2. Introduction

The industrial radiography is a non-destructive method that uses the penetrating and ionizing (X-ray or gamma-ray) radiation, that pas through the object, and the detector of the radiation. This method of NDT is very important to detect defects (internal and surface, likes porosity, cracks, lack of fusion, lack of penetration, foreign inclusions), differences in thickness, changes in structure, assembly details etc. in quality assurance of the piece, or structure conform standards, specifications or technical requirements.

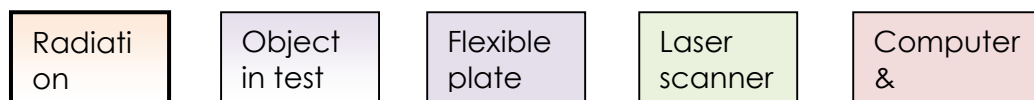
The detector can be 1. fotografic film, held in a light-tight cassette that allows the rays to pass through the piece. To develop the image on film are needed chemicals. This process is knower like conventional radiography. 2. radiation – sensitive detectors that not requiring the use of chemical to produce the image. This process is knower like digital or computer aided radiography (CR) or direct digital radiography (DR).

In digital radiography, a radiograph is created, not on conventional silver halide film, but with the use of another device that allows the radiograph to be represented as an array of discrete digital intensity values or pixels. The types are:

Film Digitization- process whereby a radiograph is produced in conventional manner on a normal sheet of industrial x-ray film, the film is than placed in a reader, the image is read and digitized for viewing and archiving on software.

Direct Radiography (DR)- the image is captured directly on flat plate and the image is transmitted directly to the computer. No intermediate steps or additional processes are required to capture the image.

Computed Radiography (CR)- uses an imaging plate, that's contains photo sensitive storage phosphors which retain the latent image. When the imaging plate is scanned with laser beam in the digitizer, the latent image information is released as visible light. This light is captured and converted into a digital stream to compute the digital image. A valuable point in the use of flexible storage phosphor plates and CR systems is that any exposure source that can be used with conventional X-ray films can also be used with this filmless technology and the flexible storage phosphors imaging plates can be directly substituted for film. They can be used in the same film holders and cassettes as those used for film and can be used in applications requiring a flexible medium, such as bending them around a circumferential specimen. This compatibility with existing sources and cassettes makes a transition from traditional film radiography to CR fairly uncomplicated and inexpensive proposition.



The fundamental parameter of CR system is the relationship between plate and dimensions of scanner's spot that can be considered as like "film system" in conventional radiography.

Quality of image is very important in interpretation of defects, in conventional radiography QI is influenced by sensitivity of film, development process, human factor over all; in CR is influenced by the kind of plate (plate IPC2 is more sensitivity than plate IPS), scanner's parameters, quality of hardware (resolution of monitor, etc) and software, here the influence of human factor is decrease.

3. CR System parameters

3.1 Exposure charts

For image quality are very important parameters such as kV, mA and exposure time. An exposure chart give us the relation 1) material thickness, 2) kilovoltage kV; 3) time of exposure and intensity, mAmin. A simple method for preparing an exposure surface is to make a series of radiographs of a stepped wedge sample consisting in a number of steps figure 1

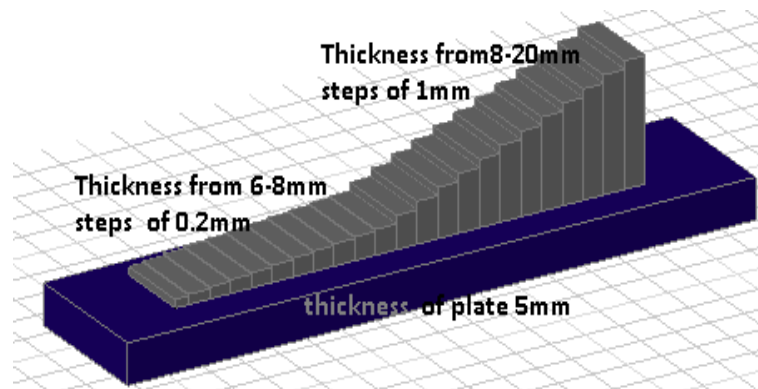


Figure 1: Stepped Wedge

We used stepped wedge from 1mm to 15mm placed over a stel plate with 5mm thickness, first two millimeters are with steps 0.2mm differences between each-other, radiographed at several different exposures at each number of kV. In figure 2 the relation between thickness-grey value and exposure(mAmin) is obtained from experimental data, where a desirable grey level is selected as the basis for the preparation of chart.

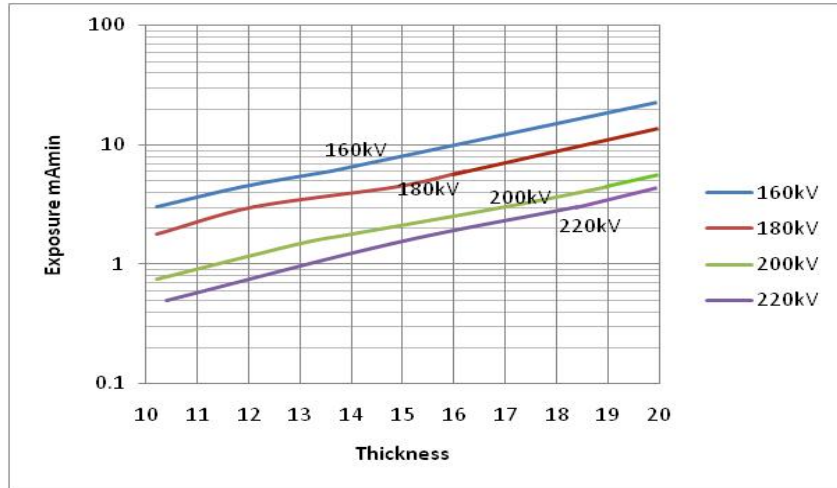
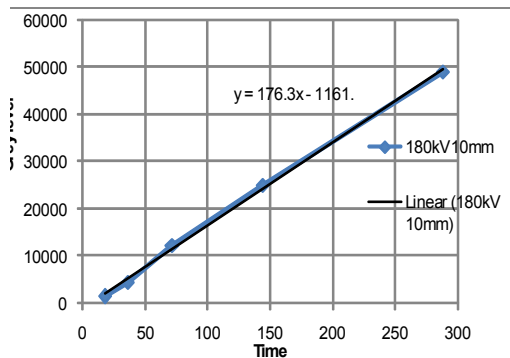


Figure2: Exposure chart based on experimental results, scanner CR50P (Pegasus), plate IPS, source-detector distance 700mm, digital value 20000counts

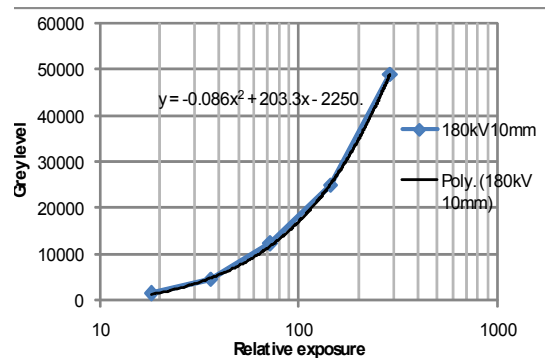
3.2 Characteristic curve

Figure 3, 4 based on experimental, data shows the characteristic curve for IPS plate scanned with CR50P 7, to express the relation between exposure and grey level. Is used the same stepped wedge radiographed in different exposure time without change of energy.



3

Figure



4

Figure

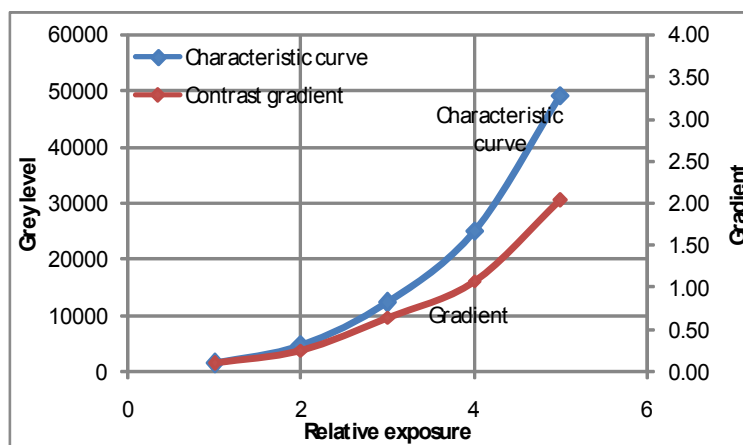


Figure 5

Based on charts is possible to interpretation, part of diagram with desirable grey level, from 25000 to 45000, over which level start the saturation of plate, is to clear that with increasing the time the grey level increase, increasing quickly the contrast figure 5.

For shorter exposure the contrast is very lower, so for good contrast have to radiographed with as longer as possible exposure.

Small thickness are penalized related to big thickness.

3.2 Energy

Chart figure 6 express the relation between thicknesses, grey level in different level of energy. Is built based on experimental for five level of energy at the same exposure.

For the same increase of energy, in our experiment is 20kV starting from 140kV, the increase of grey level is not with equal values.

Difference are bigger in exposure at high energy.

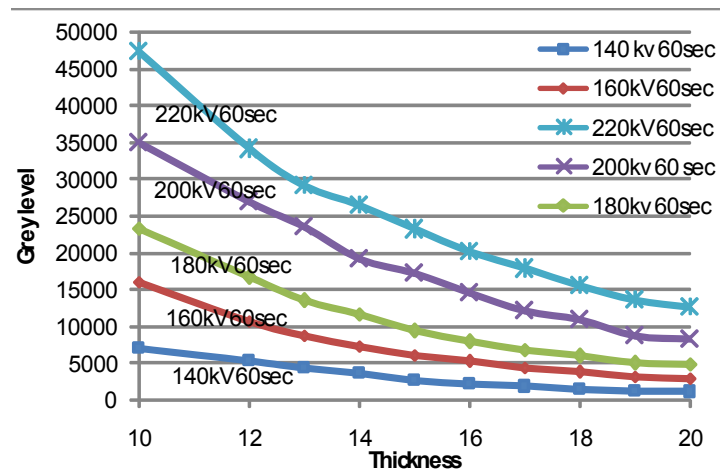


Figure 6:

Preliminary chart, different level of energy, same exposure

So the contrast obtained using higher kV is better than the contrast obtained using lower kV. The range of grey level to obtained higher contrast is from 25000 to max 45000 to, taking present that interval of time in which, from the max point, the plate can go on saturation, is very shorter.

Higher contrast means higher sensitivity to detect defects, so to obtained good contrast we need to radiographed with as higher as possible energy, higher the energy better the sensitivity.

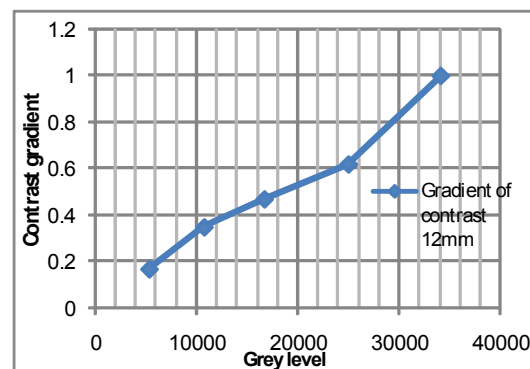
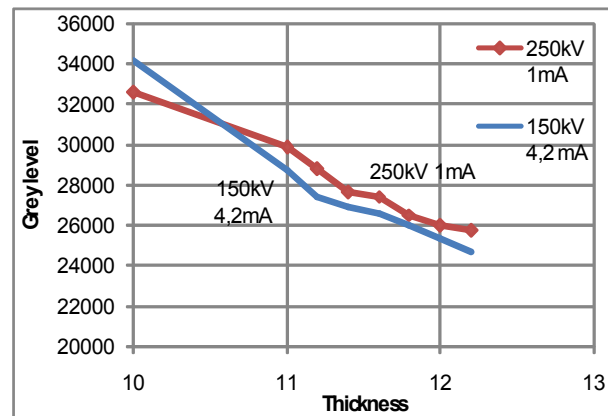


Figure 7: Contrast gradient

How is the influence of combination energy kV - intensity (mA), how change the sensitivity of defect detection.

To see that figure 8, we radio graphed stepped wedge with lower energy and high intensity (1), than with high energy and lower intensity (2). At thickness 10.5mm with the two exposure we can reach the same level of grey 31000, but when we use lower energy in this case 150kV 4.2mA 60sec related when we use higher energy, 250 kV 1mA 60sec, the contrast is higher.

To obtained good contrast, better sensitivity is good to radiographed with as low as possible energy related as high as possible intensity for the same time.



Figure

8: Influence of two combination: low energy-high intensity, and high energy-low intensity

3.3 Sensitivity

System performed parameters must be determined initially and monitoring regularly to ensure the results. According to EN 462 the best measure system is using the Duplex Wire figure 9. According to UNI EN 1478-1, the resolution criterion for the evaluation of duplex wire consists: two wires of a pair wire are resolved if the dip between the line max is greater than 20% of the max intensity.

For the plate 10mm we can see the element 7D (figure 10), diameter 0.20mm. We can guarantee the 2% sensitivity for class A. If is needed the class B the difference is only 0.04mm (diameter 0.16mm) and the digital radiography is not accepted.

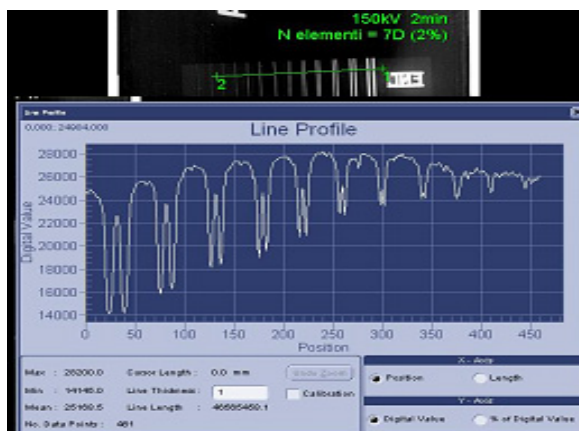


Figure 10: Image of Duplex Wire express in grey level by Line Profile



Figure 9: Duplex wire

The results express that conventional film has high sensitivity, higher resolution and good borders definition compared with CR system where the size of pixel is around 30 - 200 μ m compared with 5 μ m for the conventional film.

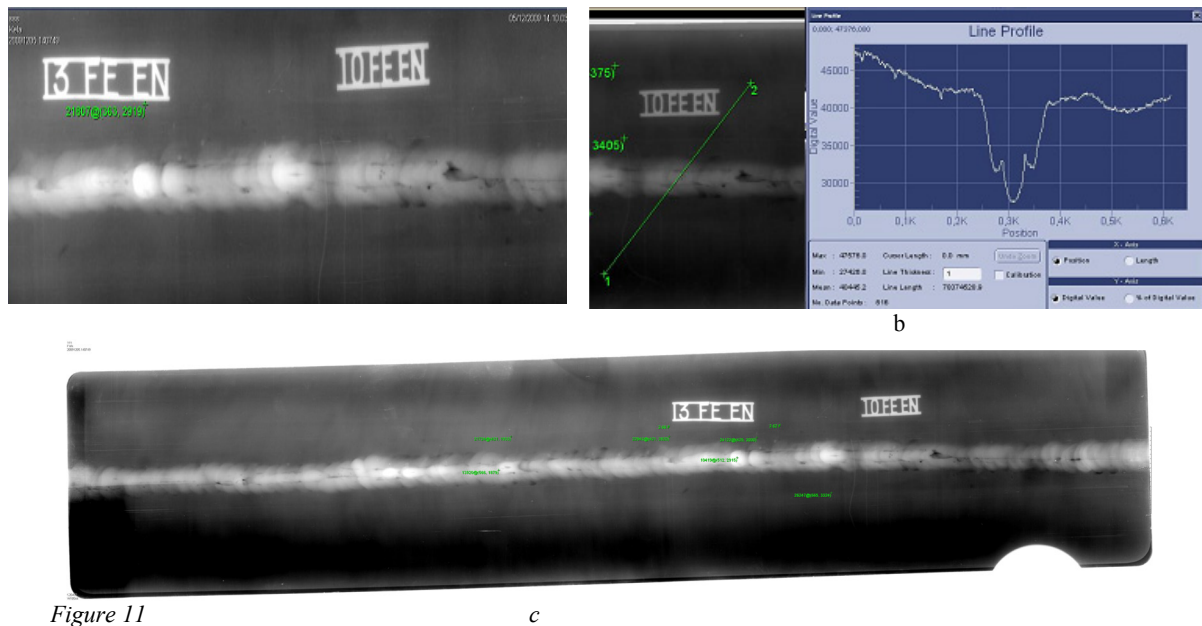
4. Experimental Tests

Inside are three different kinds of parts under exposure.

First; a weld plate with a lot of porosity, lack of inclusion figure 11a, b, c et.

Second; weld tube with diameter 296 mm figures 12.

Third; a corrodes tube under coating material diameter 48mm from heating general system of the city figure 13.



From images is proved that with post-processing is possible 2% sensitivity, and is possible to measure all defects inside.



Figure 12: Weld tube Al with diameter 296mm

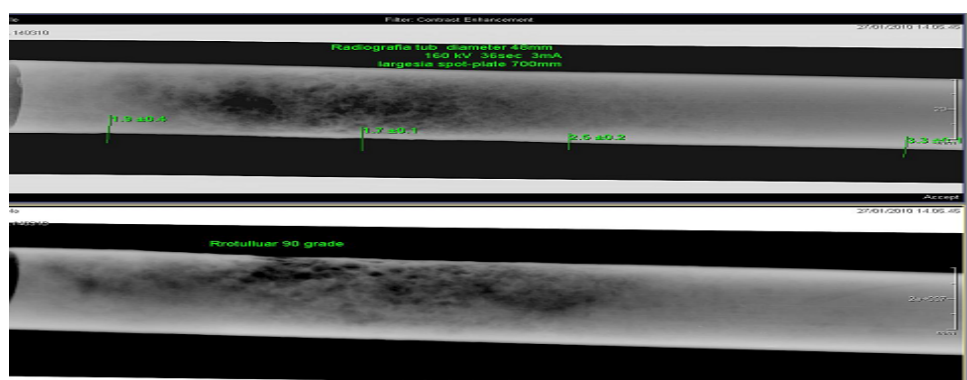


Figure 13: Corrodes tube with diameter 48mm

Tubes of heat systems with diameter 48mm and thickness 4mm are radiographed in two direction without remove coating, has been measured the thickness of tube.

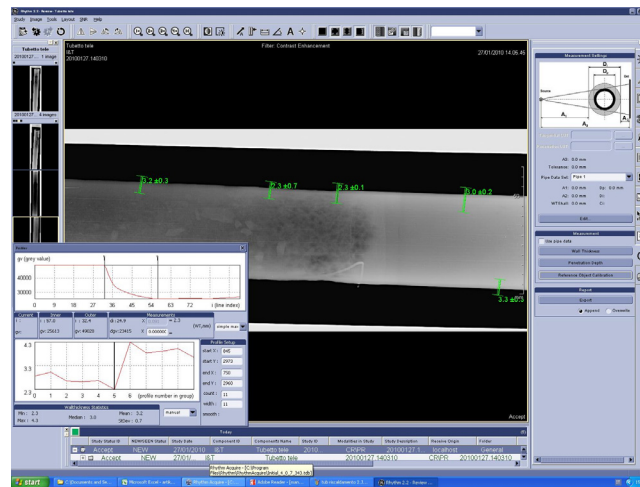


Figure 14: Corrosion dimensioning

5. Conclusions

Digital radiography has significant advantages like: exposure time reduction, no need for chemical development process what bring it to friendly to environment, easily post-processing, accurate corrosion measurement, no material limitations, no temperature limitations and no need for preparation work or remove coatings or insulation.

By the light of the obtained results we can recommended in digital radiography CR a level of grey up 25000 to 45000, because in this interval contrast is higher.

Another important consideration has been raised during the test; few cents of millimetres in wire diameter can cause a level of sensitivity more than 2% and consequently not accepted by the code.

This change in our opinion has not effective impacts on the POD of type of defects like, lack of penetration, porosity, cracks, and slag inclusion.

6. Bibliography

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Key words: digital radiography, grey level, density, contrast, gradient, exposure charts.