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Sultan Sönmez
İstanbul Teknik University, sultansonmez@itu.edu.tr, İstanbul-Turkey
Hadi Jahangiri
S&Q Mart Safety and Quality Co., jahangiri_hadi@yahoo.com, İstanbul-Turkey

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WALL THICKNESS MEASUREMENT OF CARBON STEEL PIPES BY USING DIGITAL RADIOGRAPHY

ABSTRACT

One of the major field NDT areas is pipe inspection, which involves testing for corrosion and erosion as well as examining the quality of welds in pipes. In order to perform of the wall thickness measurements that include pitting, we can use one of the two following techniques: Tangential Technique and Double Wall Technique. In this study, carbon steel pipes which have 2, 3, and 4 inch diameter were irradiated from 1m by Gamma-Ray, besides, their histogram were analyzed via Tangential Technique for different periods. Furthermore, the results were compared by gathered results which measured by Ultrasonic Test.

Keywords: Computed Radiography, Pipe Wall Thickness, Tangential Technique, Double Wall Technique, Carbon

1. INTRODUCTION

Piping is the most important means of transporting gaseous and liquid materials. Last decades, a large amount of piping construction has been performed in the world. A significant, proportion of piping is used in power stations and transporting. It is very important problem in the oil and gas process industries is how to investigate insulated piping for corrosion under internal erosion and insulation. Generally, the pipe is disruption due to the diversity of mechanisms, or internal erosion from the flowing fluids. The wall thickness monitoring and measurement are the most important parameters in a pipeline. This phenomenon is particular when the corrosive liquid flows through the pipe. This piping is generally covered by thick insulation materials. Only radiographic technique provides physical examination without costly removal of insulation material during operation of the facilities [1]. In order to apply Wall Thickness Measurements, we can use one of the two following techniques: Tangential Technique and Double Wall Technique. The situation where there is a huge diversity between the minimum thickness of material to be penetrated for the outer wall identity, and the extensive amount of material to be penetrated for the inner wall identification creates a conflict for each of these measurements. Development and propagation of tangential radiography and double wall techniques are very useful to assess corrosion, erosion, deposits and blockage of pipes [1 and 3]. A special solution when using Digital Radiography, which make possible automatic grabbing of more than one image and gathering all the data necessary for exact tangential wall thickness measurement, double wall examination, as well as automatic measurement calibration methods, is presented [2 and 4].

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- **Tangential Technique:** Tangential Technique can measure the pipe diameter and the wall thicknesses. As shown in formula 1 and 2, X is material penetration required distance, R is outer diameter r is inner diameter and t is pipe wall thickness. In this technique gamma source should be in front of pipe on the center line. In this method, both wall thicknesses can be measured by one shooting.

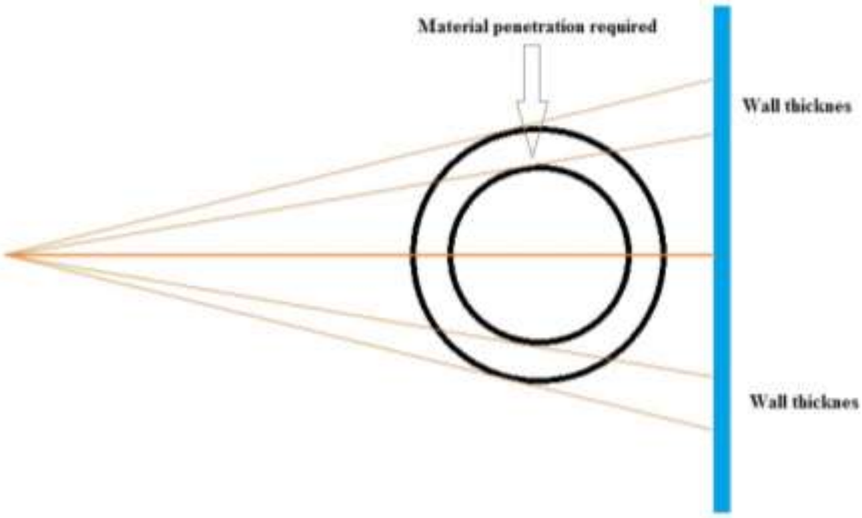

Figure 1. Schematic of tangential technique

$$X = 2.\sqrt{2R.t - t^2} \quad (1)$$
$$X = 2.\sqrt{R^2 - r^2} \quad (2)$$

- **Double Wall Technique:** In this technique wall thickness can be measured too but one shoot is necessary for each wall. This method is used in pipes with larger diameter.

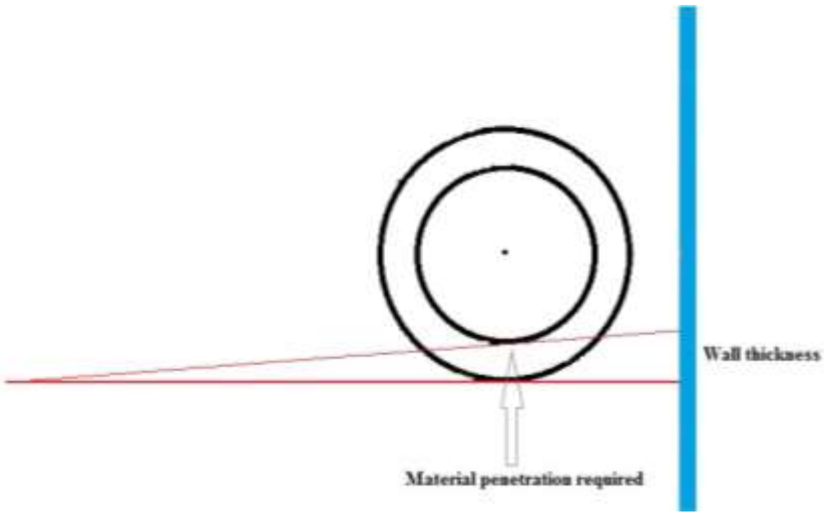

Figure 2. Schematic of double wall technique

In this method gamma source should be located perpendicular to the wall of pipe which would be measured. Therefore, energy will through shorter distance and loosing of energy will be least. The formulas 1 and 2 are usable in this technique too. In this study wall thickness of 2, 3, and 4 inch diameter carbon steel pipes were irradiated from 1m by Gamma-Ray (γ- ray) and Double Wall Technique in different periods(90, 120, and etc) and their histogram were analyzed and the results were compared by gathered results which measured by Ultrasonic Test (UT).

2. RESEARCH SIGNIFICANCE

Digital Radiography is new methods which used industrially in piping inspection and corrosion analyzing. Up to now, Radiography was used as qualitative method but this technique results are quantitative. According to this study, results are compared by ultrasonic inspection. Meantime, effect of irradiation time and diameter of pipes on Caught histograms were analyzed.

3. EXPERIMENTAL STUDY

Three different sizes (2, 3 and 4 inch) of Carbon Steel pipes are used in this study. They are shown in Figure 3. Whole of pipes are schedule 40.

a b c

Figure 3. Carbon Steel pipes with Different diameter
a) 2 inch, b) 3 inch, c) 4 inch

Carestream™ INDUSTREX HPX 1 is used as digital radiography scanner. HPX-1 has the capability to handle long plates, short plates, rigid cassettes and flexible plates all in a single system. Flex XL Blue digital imaging plate features over 30% higher resolutions than Flex HR plate for use in the most demanding applications. Iridium-192 (50 curium) is used as Gamma radiography source. The SUIU™ CTS-30A as the ultrasonic wall thickness measurement device with 5 MHz frequency and TR probe was used. Gamma irradiation was applied from 1 meter (m) in whole inspections.

4. FINDINGS AND DISCUSSIONS

Wall thicknesses of the all pipes for different diameters were measured ten times by ultrasonic thickness measurement device. Wall thickness values for 2, 3, and 4 inch diameter pipes are given as average 3.9, 5.5 and 6.0mm respectively (Table 1-3). Standard deviations of the all measured values are low and at negligible value. Wall thicknesses of all pipes were also measured by using double wall double image (DWDI) technique. When DWDI tests performed, the optimum exposure duration for 2, 3 and 4inch diameter pipe were obtained after 120 sec, 180 sec and 300 sec respectively. Standard deviation (SD) values of the digital radiography are decrease with increasing exposure time. At the same time, SD values for same exposure duration increased with pipe diameter increment. For instance after 90 sec irradiation, 2, 3 and 4 inch pipes SD values are 0.5, 0.9 and 1.5 mm respectively. Wall thickness histogram and digital radiography images of pipes for different diameter are shown in Figure 2. The histograms were drawn from the intensity difference of Digital Radiography images that automaticly generated by Carestream™ program (Figure 4. a,c and e). The dark areas of the pipe's digital radiography have the lowest intensity, adnt the light regions have the highest values.

Table 1. Pipe (2" ∅) wall thickness values

	Exposure Time (sec)	Wall Thickness Measured by D-RT (mm)	Wall Thickness Measured by UT (mm)
1	45	3.7±1.5	3.9±0.1
2	60	3.7±0.7	
3	90	3.8±0.5	
4	120	3.9±0.2	
5	180	3.9±0.2	

Table 2. Pipe (3" ∅) wall thickness values

	Exposure Time (sec)	Wall Thickness Measured by D-RT (mm)	Wall Thickness Measured by UT (mm)
1	45	5.3±1.7	5.5±0.1
2	60	5.3±1.2	
3	90	5.4±0.9	
4	120	5.4±0.7	
5	180	5.5±0.2	
6	240	5.5±0.2	

Table 3. Pipe (4" ∅) wall thickness values

	Exposure Time (sec)	Wall Thickness Measured by D-RT (mm)	Wall Thickness Measured by UT (mm)
1	90	5.8±1.5	6.0±0.1
2	20	5.9±1.1	
3	240	6.0±0.6	
4	300	6.0±0.2	
5	360	6.0±0.1	

Gamma ray lose energy during crossing the pipe it cause to get darker regions. As shown in Figure 4-b, d and f wall of pipe is the darkest regions. It means that the longest way is belong to the walls which this distance can calculated by formula 1 and 2. The edge of wall should be completly clear during measurment vise verca if the edge of wall are not seen clearly the calculated values are not exact. According to Table 1, 2 and 3, the sharpest wall edge are appeared in the 120, 180 and 300 sec for 2, 3 and 4 inch diameters.Furthermore, long perid of gamma exposure causes to reduce the noise sametime occur smooth curve in the middle and sharp edge at the sides of the histogram. Meantime radiation of gamma ray more than optimum not only have not possitive effect on accurancy of measument but also may cause negetive effects like scatteing and noise.

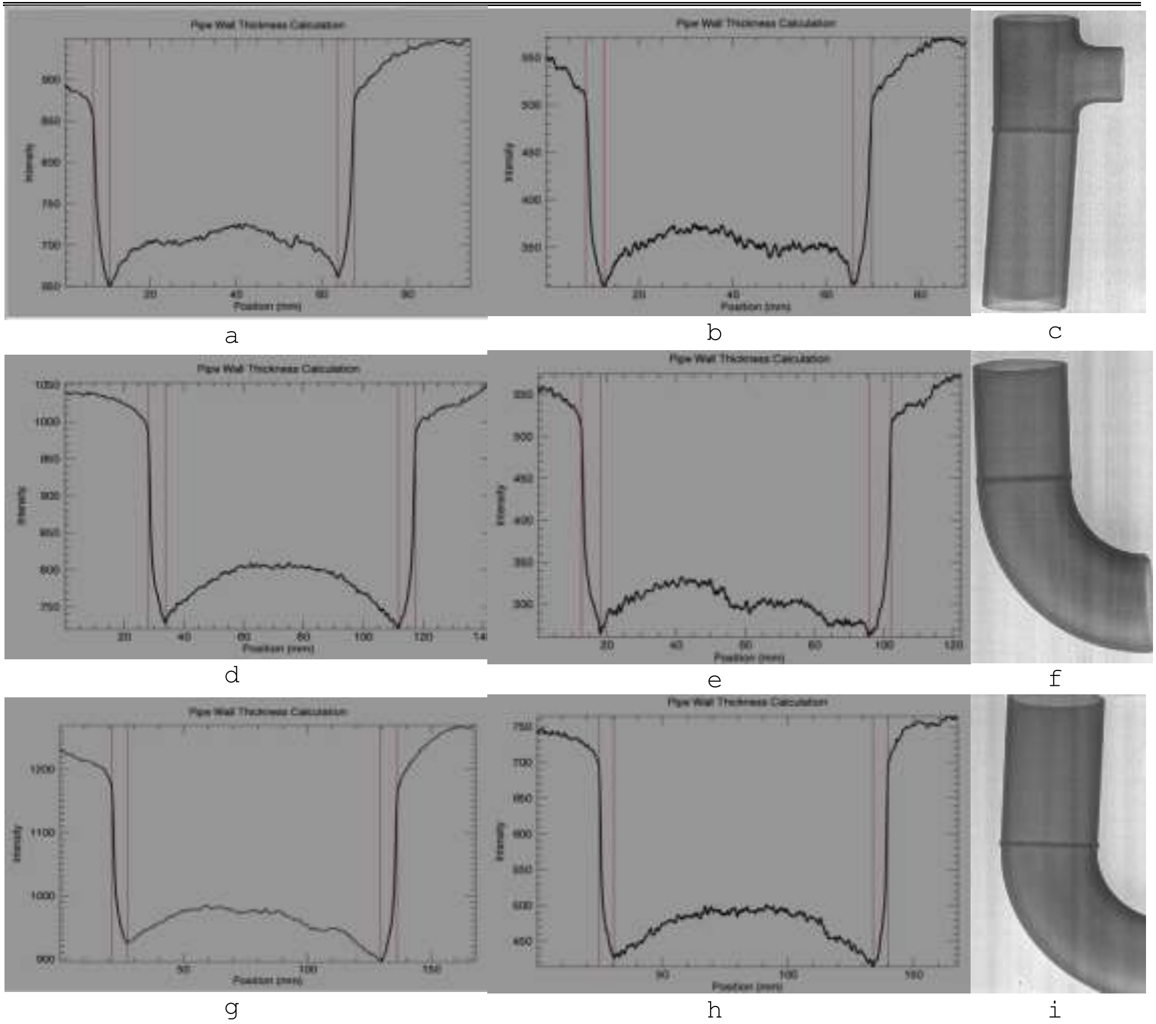

Figure 4. Wall thickness histogram and digital radiography images of pipes

Pipe (2″ ∅):a- after 120 sec irradiation
b- after 45 sec irradiation
c- digital radiography images

Pipe (3″ ∅):d- after 180 sec irradiation
e- after 60 sec irradiation
f- digital radiography images

Pipe (4″ ∅):g- after 300 sec irradiation
h- after 200 sec irradiation
i- digital radiography images

5. CONCLUSION AND RECOMMENDATIONS

On the basis of the results reported in the present investigation, the following conclusions can be drawn:

- Optimum exposure duration for wall thickness values measurement for 2, 3, and 4 inch diameter pipes from 1m by Iridium-192 (50 curium) are 120sec, 180sec and 300sec.
- Standard deviation (SD) values of the digital radiography are decrease with increasing exposure time.
- Standard deviation values for same exposure duration increased with pipe diameter increment.

- Long perid of gamma exposure causes to reduce the noise sametime occur smooth curve in the middle and sharp edge at the sides of the histogram.
- Gamma irradiation more than optimum duration cause negetive effects.

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NOTICE
The study had been previously presented in the XIV. International Corrosion Symposium (KORSEM 2016) in Bayburt.

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