Quality evaluation of crude oil pipeline welding joints by using NDT techniques, with a specific emphasis on X-ray radiography

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ABSTRACT

The objective of this study is to evaluate the quality of crude oil pipeline welding joints used in Zueitina oil company was performed by two methods of NDT techniques, with a specific emphasis on X-ray radiography and PAUT ultrasound. Examining the effectiveness of NDT in detecting defects and These two tools enabled to identify the causes of welding defects as well as to determine the frequency of their occurrence and to identify the most serious welding faults and defects. Both methods – technical should reveal shortcomings in technological aspect. Their use should contribute to improving the welding process of pipes in operation and to increasing the safety of piping systems.

KEYWORDS: Quality, weld joints of the pipes, welding defects, bob-destructive testing, Zueitina oil company.

1. INTRODUCTION

Quality is not only a term for product´s characteristics, but also for the people who create this product and use it correctly in practice [1]. The quality of weld product should not be limited to its final inspection, but it should include all process proposals [2] and production strategies [3]. According to the authors [1-4], the product price consists of a combination of several different items. Between them, time needed for an adequate control of the product can be one of the most significant items, which can get expensive. In addition, verification of the quality of welding processes is not easy and therefore the specification of welding quality and inspection requirements is very important. It is necessary to ensure control of the whole process [5-6].

Crude oil pipelines play a vital role in the transportation of this valuable natural resource, ensuring its efficient delivery from extraction sites to refineries and distribution centers. The integrity of these pipelines is of utmost importance to prevent leaks, spills, and other potential hazards that can have severe environmental and economic consequences. Welding joints, being critical components of pipeline infrastructure, require thorough evaluation to ensure their quality and reliability [7-8].

Non-destructive testing (NDT) techniques have emerged as essential tools in the assessment of welding joints, allowing for the detection of defects and anomalies without causing damage to the tested materials. Among the various NDT techniques available, X-ray radiography has proven to be particularly effective in providing detailed information about the internal structure, integrity, and potential flaws of pipeline welding joints [9-10]. This study was conducted, in collaboration with Zueitina oil company, a prominent player in the pipeline infrastructure space. Access to their X-ray photos and results allows for a comprehensive analysis of the welding joints and facilitates the evaluation of the NDT techniques employed.

2. MATERIAL AND METHODOLOGY

2.1 Methodology

The methodology described in the provided text is comprehensive and well-structured. It incorporates various elements of methodology, including paper design and approach, sample selection and data collection, evaluation of X-ray radiography techniques, and data analysis and interpretation. Let's review each component:

2.2 Paper design and approach

The study adopts a comparative case study design, which is appropriate for evaluating the effectiveness and reliability of X-ray radiography techniques used by Zueitina oil company for pipeline welding joint evaluation. The description highlights the advantages of the case study approach, such as in-depth analysis and the identification of strengths and weaknesses. The paper approach is qualitative, aligning with the study's objectives and the nature of the data collected.

2.3 Sampling strategy and sample size

The sample selection focuses on Zueitina oil company, which has expertise in evaluating crude oil pipeline welding joints using X-ray radiography techniques. The criteria for sample selection are clear, emphasizing reputation, expertise, and experience. The combination of primary data from interviews and secondary data from various sources enhances the comprehensiveness of data collection.

2.4 Radiographic testing:

Radiographic Testing (RT) as a widely used non-destructive testing (NDT) technique for evaluating welding joints in crude oil pipelines. Specifically, it outlines the principles of RT, where X-ray or gamma-ray radiation is employed to generate detailed images of the joints’ internal structure. Furthermore, we discuss the necessary equipment, techniques, andthe interpretation of radiographic images,emphasizing both the advantages and challenges of using RT for pipeline inspection.

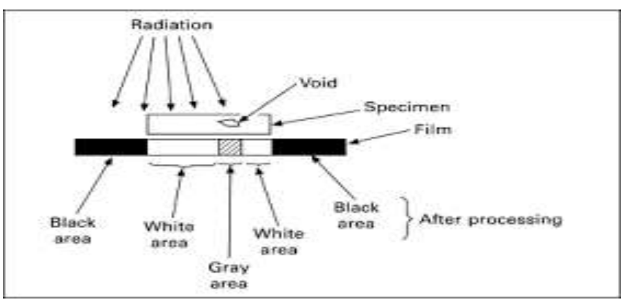

Figure (1) Radiographic testing

3.WELDING DEFECTS AND IMPLICATIONS:

Welding discontinuities are divided in following six groups:

1. Lack of fusion,
2. Porosity
3. Cracks,
4. Under cuts

Welding defects can be classified in to two types as external and internal defects. External welding defects occur on the upper surface of the welded work. Surface defects of the weld joints are detected by the naked eye or by aid of tools such as magnifying glasses. Internal welding defects occur under the surface of the welded work. These can be detected only after metallographic preparation of the weld joint samples. Figure 1 shows typical types of defects of the weld joints

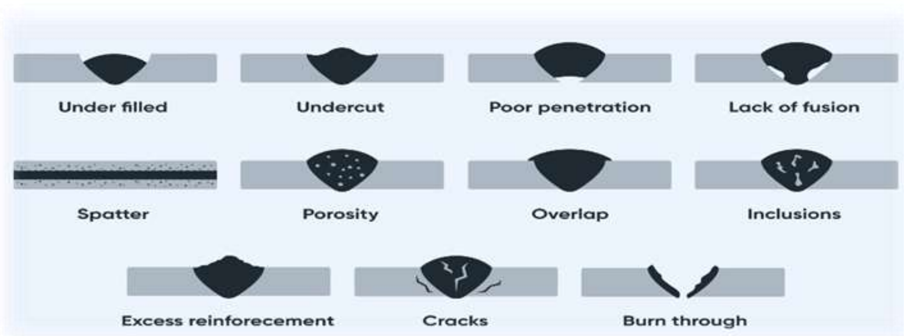

Figure (2) Welding defects and implications

4. RESULTS AND DISCUSSION

Welding defects were visually observed from the outside and, after the pipes cut, from the inside of the pipe at 10x magnification. In Figure 3,4,5 and 6 are exam-ples of observed welds. Mainly, defects in the shape and dimensions of the welds were visually observed. These defects were not assessed separately in the experiment. We focused on the evaluation of internal defects on prepared sections of the weld joints by X-ray radiography techniques.

Figure (3) shows a cross-section and a side view of the second weld joint and the locations of the three discontinuities on it, which are a fracture in the upper region of the weld (toe crack), slag inclusions, and a second fracture in the upper region of the weld, according to their position in order, starting from zero.

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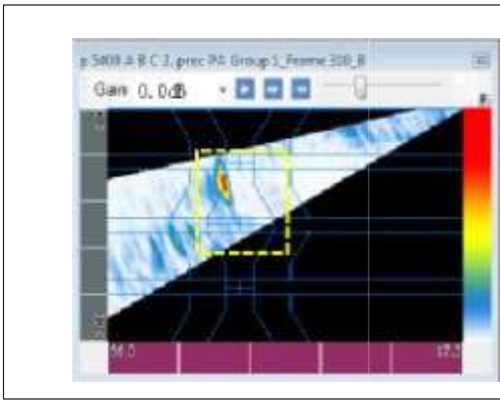
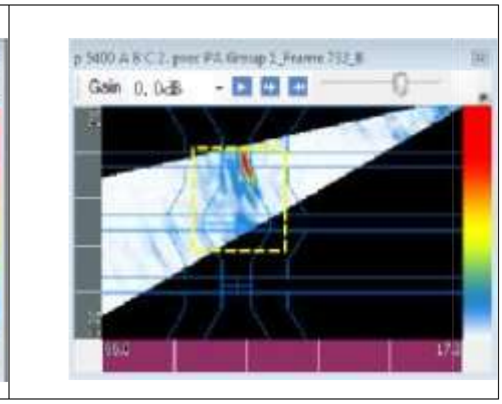

B **C**

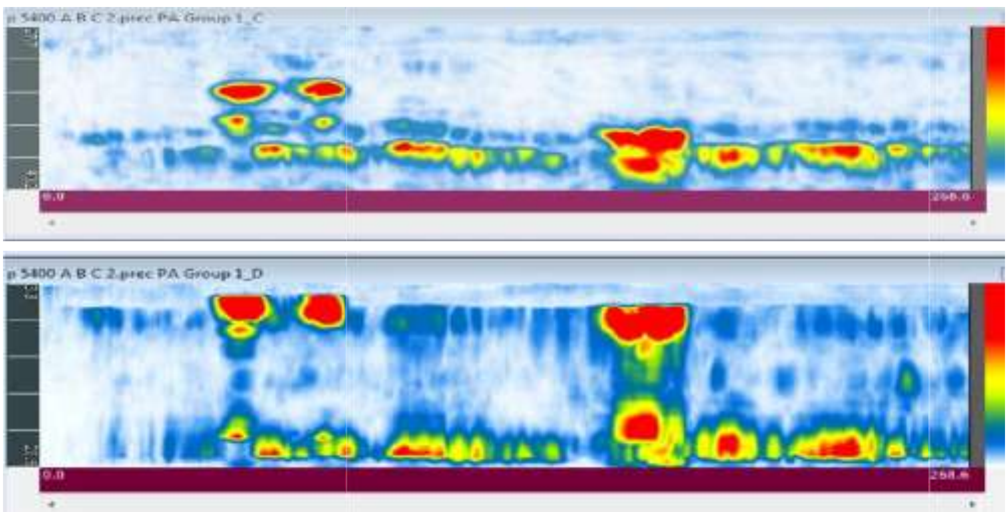

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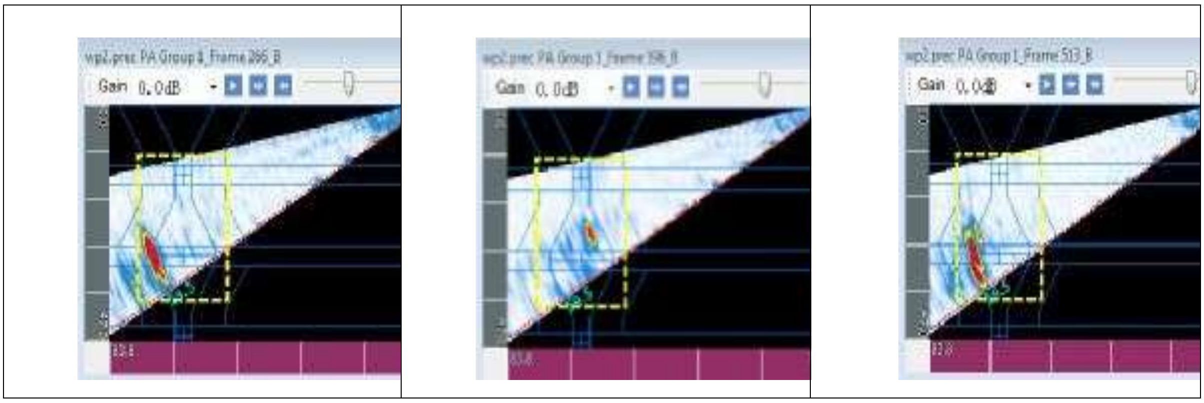
Figure (3) : The result of testing the first weld joint by radiography and PAUT ultrasound and the signs of the two visible interruptions in each of the two mentioned test techniques.

Figure (4) shows a cross-section and side view of the third weld joint and the locations of the four discontinuities on it, which are a fracture in the upper area of the weld (toe crack), slag inclusions, and a second fracture in the root of the weld (root crack) and slag inclusions, according to their position, respectively. Starting from scratch.

A



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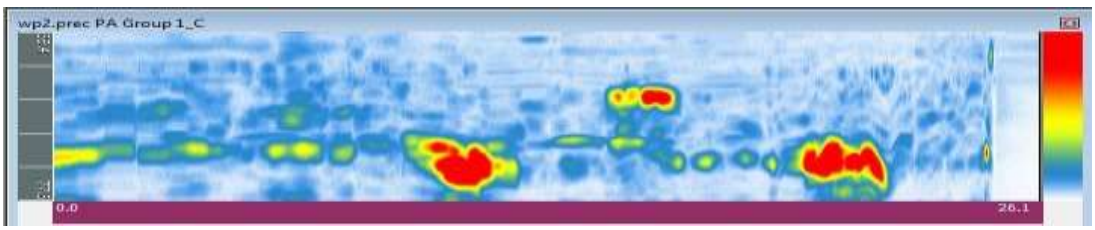

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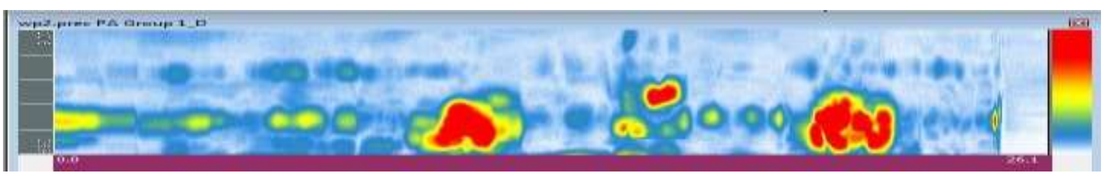

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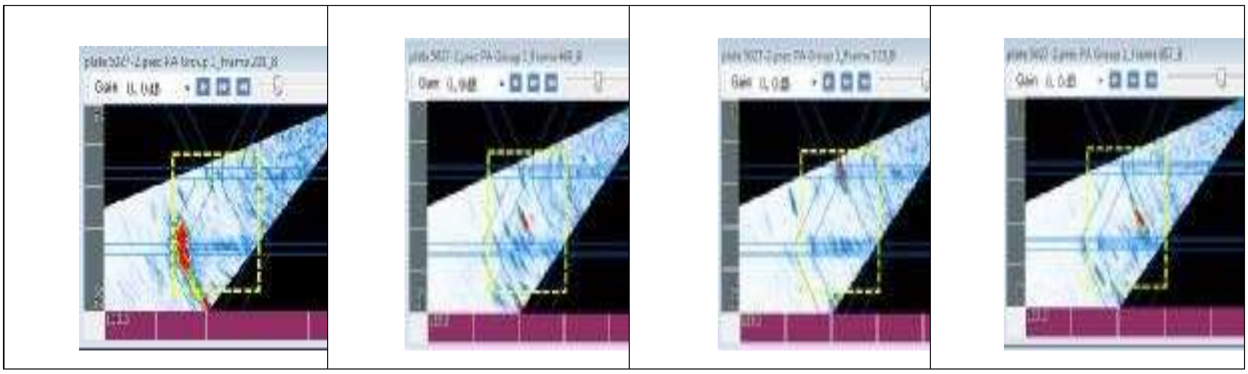
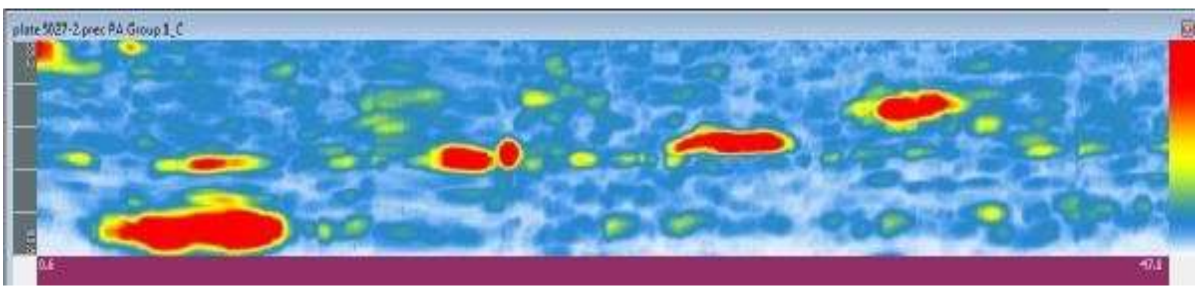
Figure (4): The result of testing the second welded joint using radiography and PAUT ultrasound, and visible interruption signals in each of the two mentioned test techniques.

Figure (5) shows the radiograph and ultrasound images in the B, C & D scanning systems resulting from testing the third weld joint by radiography and directed beam ultrasound, respectively. As the figure shows, the radiograph revealed two signs of discontinuity resulting from the presence of slag inclusions in the weld joint, and recorded a weakly clear signal of the fracture in the root area. Likewise, no signal indicating the presence of the fracture in the upper layer of the weld was seen. While, on the other hand, through the ultrasound images with directed beams, the signs of the four discontinuities, their nature, locations, and dimensions of each of them in the weld joint were clearly seen.

A



B C D E



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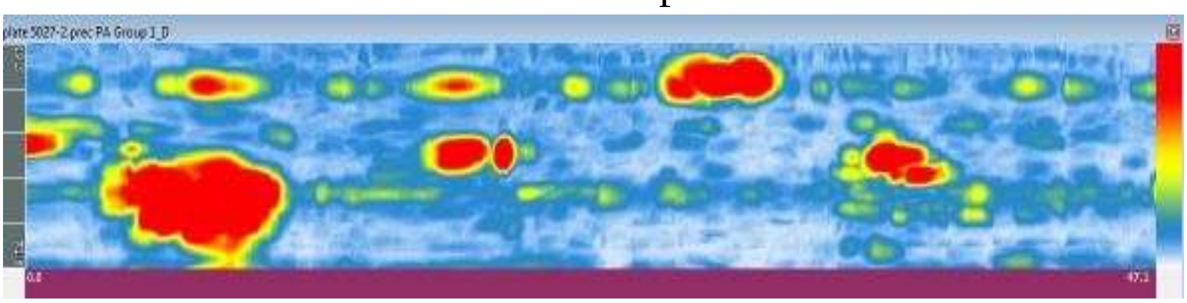

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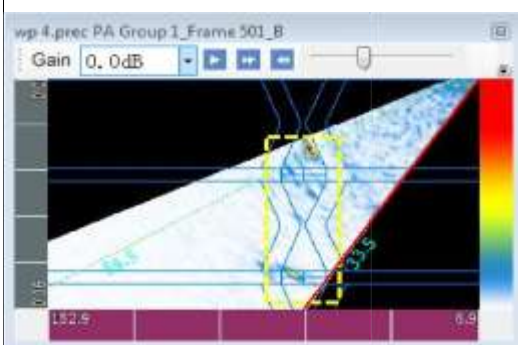
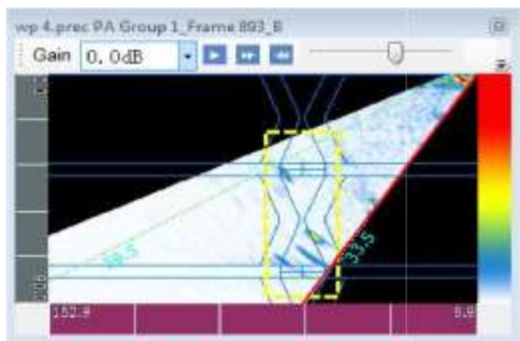
Figure (5): Test result of the third welded joint using radiography and guided beam ultrasoundPAUT and visual interruption signals in both test techniques mentioned.

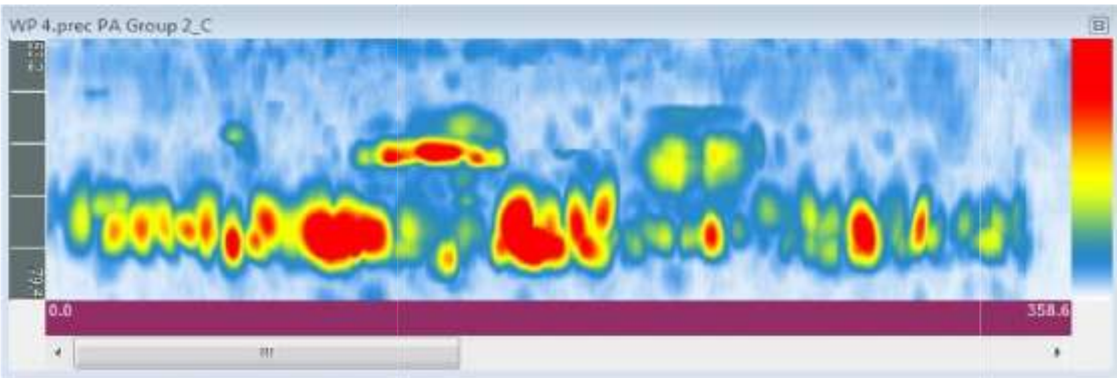
Figure (6) shows the radiograph and ultrasound images in the B, C & D scanning systems resulting from testing the fourth welded joint by radiography and guided beam ultrasound, respectively. As shown in the figure, the radiograph revealed the two discontinuity signals resulting from the presence of slag content in the weld joint. On the other hand, the test images using ultrasound with directed beams also revealed the two discontinuity signals, clearly showing their nature, position and dimensions in the weld joint.

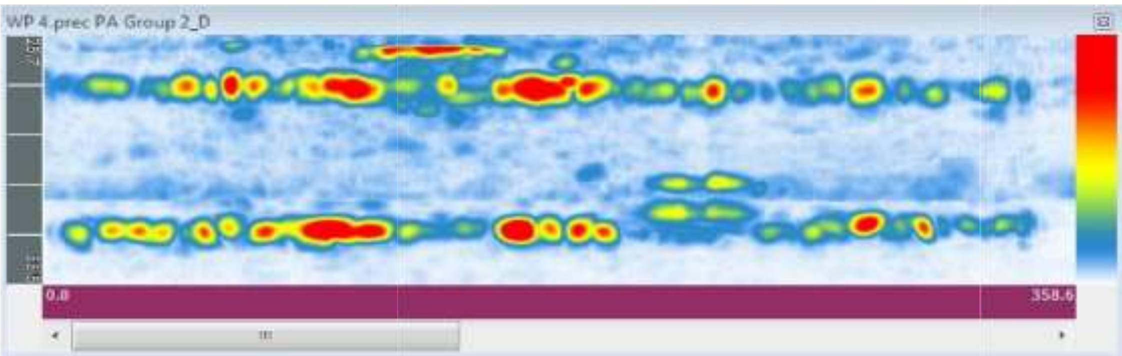
A





B C





D

Figure (6) : The result of testing the fourth welded joint using radiography ultrasound, and visible interruption signals in mentioned test technique.

Table (1) summarizes the ability to detect defects in each of the four welded joints using radiography and guided beam ultrasound and the ease of characterizing these defects.

Table 1: Ability to detect defects present in each of the four welded joints for testing technique

Weld No.	defect	Radiography (X-rays)	
		Detectability	Description of defects
1	Lack of root fusion	Good	Good
	Root crack	Good	Good
2	Root crack	Good	Good
	Toe crack	Good	Good
	Slag inclusion	Good	Good
3	Toe crack	Good	Good
	Slag inclusion	Good	Good
	Root crack	Good	Good
4	Slag inclusion	Good	Good
	Slag inclusion	Good	Good
	Slag inclusion	Good	Good

5. CONCLUSION

The combination of the two methods for evaluating the quality of the weld joints of the pipes was to reveal the causes of failures and defects and offer solutions to increase the quality of the weld joints. The technical methods were identifying and welding defects on the joins of welds detected and classified into the groups, classes and subgroups. From the detection and classification ofwelding defects, we created the Pareto diagram which helped us to identify the three most common types of welding defects (vital minority) affecting the overall quality of welding steel pipes. Combination of technical methods offers a view of the issue from a broader angle. This presupposes that the problems that have arisen will be solved more comprehensively.

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