



PHASED ARRAY AND TOFD IN LIEU OF RT FABRICATION AND IN-SERVICE

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ABSTRACT

This paper will discuss the replacement of Radiography by Phased Array (PA) and Time of Flight Diffraction (TOFD). Information will be given about the inspection requirements for pre-service and in-service inspections. Based on these requirements, SGS has developed a PA inspection system for the inspection of boiler tube welds. The advantages and disadvantages of this system will be discussed by giving information about general advantages, combined with an overview about the differences in detection and sizing of different type of defects.

As the restrictions in the use of Industrial Radiography (RT) has increased over the years, the need for alternative weld inspections methods and techniques such as Time of Flight Diffraction (TOFD) and Phased Array (PA) has become more evident.

Generally, new developments in Non-Destructive Testing (NDT) are driven by improved performance of the new technique and cost reduction.

For the pre-service inspection cost reduction is generally given more consideration than improved performance, the rationale being that inspections are acceptable as long as welding satisfies the requirements of the applicable codes and standards.

For in-service inspection, the performance and accuracy of the inspection is considered more critical as the risk of failure between shut downs shall be as small as possible, therefore, requiring a higher probability of detection and more accurate sizing of indication.

When Phased Array and Time of Flight Diffraction techniques are performed correctly, the quality of performance is superior when compared with radiography. This means that the confidence level of the structural integrity of products inspected with TOFD or PA is higher than those inspected using radiography. The inspection costs of PA and/or TOFD are typically higher than the costs of conventional RT, however, because dangerous radiation is not a

factor when using the advanced techniques, there can be huge savings associated preventing the disruption of works within the area. In addition, the speed of PA and TOFD shortens overall inspection time and also eliminates the lost time associated with RT. An inherent factor of using a more accurate inspection technique is the higher repair rate due to the more stringent acceptance criteria of PA and TOFD. Increased confidence in the integrity of the product offsets the relatively small rise of repairs thereby decreasing any significant influence total costs.

It's important to note that pre-service inspections are not intended to detect all defects that may lead to failure. This is an impossible reality, as no NDT technique has a 100% detection rate. In order to test at 100% accuracy, each component would require individual acceptance criteria based purely on its unique "fit for service" acceptability as operation conditions, material, alloys and other factors vary.

For in-service inspection however, a higher detection rate is necessary in order to prevent failure prior to the next scheduled shutdown. This can only be realised when supplementary NDT techniques are used in parallel.

In-service inspection places less importance on normal acceptance criteria based on the size of a detectable indication. When critical defects are

detected in such an inspection, the remaining life time of a component must be calculated. This remaining life time calculation is the main reason for this type of inspection, as it is not intended for the detection weld defects unreported during the initial NDT inspection.

Pre-service inspection requires acceptance criteria to confirm welds are meeting the requirements of relevant codes and standards and workmanship is acceptable. Here we have several options:

- 1) Use ASME acceptance criteria e.g. CC2235-9 for pressure piping and vessels.
 - a. The problem with this is that the acceptance criteria were developed in a wall thickness range starting at 12.4 mm although technically it is no problem to use TOFD and PA from 4 mm and upward.
- 2) Use European codes and standards; Minimum wall thickness is 6 mm.
- 3) Define your own acceptance criteria.
 - a. Based on the confirmation of acceptable workmanship
 - b. Based on the determination of fitness for purpose of the product

In the presentation, the quality performance of PA will be illustrated by an example in which radiography has been replaced by PA.

SGS HAS DEVELOPED A WELD INSPECTION SYSTEM USING PHASED ARRAY FOR BOILER TUBE WELDS.

THE SYSTEM HAS THE FOLLOWING

FEATURES

- Covers pipes from 21.3 mm (0.84 in) to 114.3 mm (4.5 in) OD
- Operates within 13 mm (0.5 in) clearance (on all standard pipes), permitting inspections in limited access areas
- Can hold two Phased Array probes for complete weld coverage in one pass
- Can be configured to make one-sided inspections for pipe-to-component evaluations
- Design provides stable and constant pressure around the full circumference of the pipe
- Can be manipulated from one side of a pipe
- Spring-loaded scanner can be used on ferromagnetic and non-ferromagnetic pipes
- Encoder resolution of 32 steps/mm
- Two encoders on the scanner

BENEFITS

- No health and safety implications with using ionising radiation
- Other work in vicinity mustn't be suspended during inspection
- Elimination of radiation protection measures
- Equal or higher reliability of examination in comparison to radiography
- High cost savings
- 100% coverage of weld
- Fast inspection nearly carried out in real time
- Possible to characterise and size many defects
- Two dimensional sizing
- Direct assessment after test
- Possible to produce both hard- and soft-copy results

DRAWBACKS

- Tube wall thickness has to be >4.5 mm for detection and characterisation of defects and bore chamfering must be handled with care
- Skilled operators not readily available as technique is new
- Doesn't quite match radiography in detection and characterisation of inclusions and gas pores

COMPARISON WITH RT PRODUCED THE FOLLOWING OVERVIEW

	PHASED ARRAY		RADIOGRAPHY	
	DETECTABILITY	CHARACTERISATION	DETECTABILITY	CHARACTERISATION
POROSITY	Acceptable	Acceptable	Good	Good
INCLUSIONS	Acceptable	Acceptable	Good	Good
LACK OF ROOT FUSION	Good	Good	Poor	Poor
LACK OF SIDE WALL FUSION	Good	Good	Poor	Poor
WELD TOE CRACK	Good	Good	Acceptable	good
EXCESS PENETRATION	Acceptable	Acceptable	Good	Good
WORMHOLE/PIPING	Acceptable	Acceptable	Good	Good
WELD ROOT CRACK	Good	Good	Acceptable	Acceptable
ROOT CONCAVITY	Good	Acceptable	Acceptable	Acceptable
LACK OF ROOT PENETRATION	Good	Good	Good	Good

CONCLUSIONS

- PA dramatically reduces health and safety implications
- PA offers advantages in saving time and money
- Advantages and limitations of each technique have been presented
- Radiography offers benefits for detection of inclusions and porosity
- PA can detect all defect types and characterise them in accordance with acceptance criteria

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