

QUALIFICATION OF ADVANCED ULTRASONIC TESTING ACCORDING TO VARIOUS GUIDELINES

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ABSTRACT

Since many years advanced ultrasonic testing is used in various industries, mostly in nuclear industry. Specific examination problems resulted in the development of advanced ultrasonic testing procedures. In many cases these were subject to qualification according to applicable codes, standards, rules, or even contractual agreement, each one with their specific requirements to fulfil. This paper summarizes and synthesizes most of the qualifications performed by Vinçotte the last decades and presents some conclusions based on qualification experiences.

INTRODUCTION

This story starts in the early nineties when the NDT world was changing considerably due to the results of the PISC Programme (Program for the Inspection of Steel Components) [1] and other studies worldwide. It was in the same period that the Performance Demonstration Initiative (PDI) was formed by US Utilities to implement the performance demonstration requirements of the ASME Code, Section XI, Appendix VIII [2]. Meanwhile in Europe, ENIQ was brought to life as the importance of the issue of qualification of NDE inspection systems (procedures, equipment and personnel) used in ISI programmes for nuclear power plants was identified [3].

It is with these programmes in place that NDT companies had to qualify their procedures and personnel according to the applicable codes. Each qualification, the one more challenging than the other, was an adventure on its own, not for the authors only, but for the whole team.

THE NINETIES

Although not a qualification, the results of the PISC III, Round Robin Testing on Austenitic Steel Testing of the R&D division of Vinçotte are to be mentioned as they had their influence on future qualifications. Stainless steel components of PWR primary circuit sections were inspected by mechanised examination using focussed TRL probes (Transmitter/Receiver Longitudinal wave). These procedures provided an excellent detection and low false call rate.

In the mid nineties a RRT was organised by the Swedish utilities (Ringhals) for the examination of PWR pump casing welds, pipe to elbow welds and nozzle to primary pipe welds. The results of this RRT brought Vinçotte to a qualification at the utilities location, supervised by SQC (Swedish Qualification Centre). The procedures and personnel were to qualify on representative flawed samples, a full-scale pump mock-up with 2 pump casing welds and a pipe to elbow weld. A 7-axis robot carried the probes, fully submerged for accessing the welds from the inside (figure 1). Hard work from all parties resulted in May 1997 to qualified procedures and qualified personnel. This qualification resulted in various examinations in the period of '97 to '99 [4].

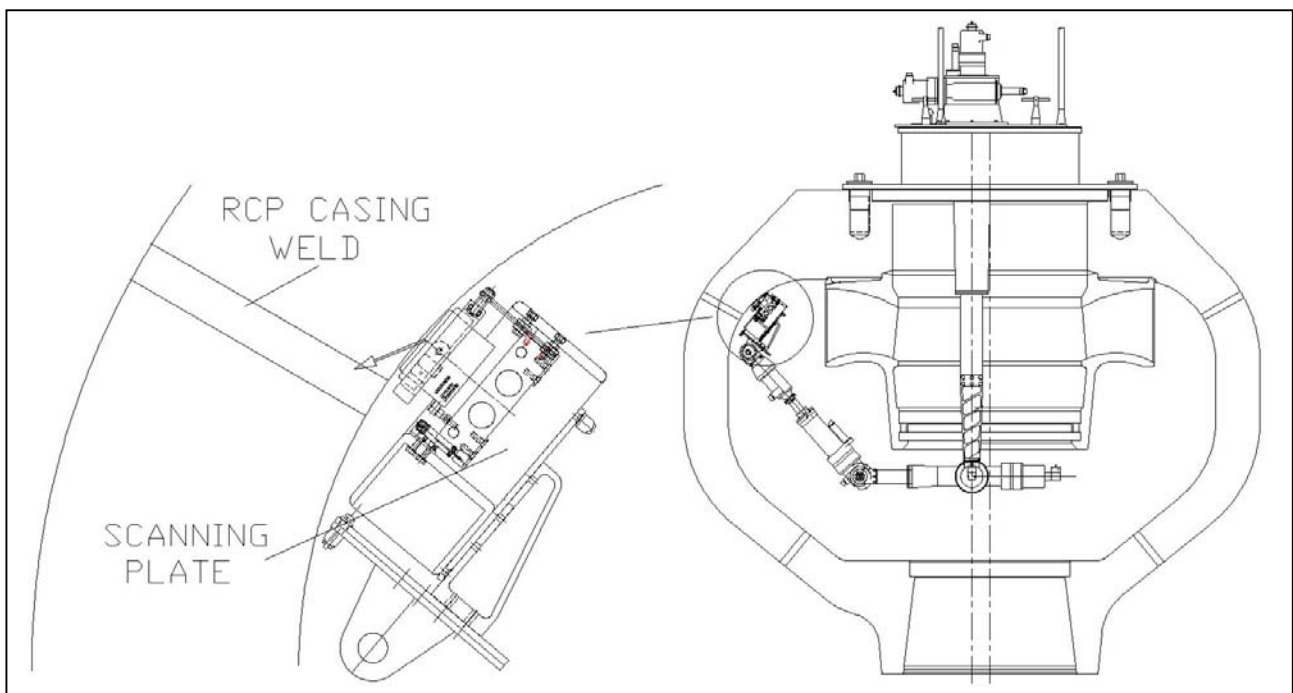


Figure 1

Also in the mid nineties, the R&D division of Vinçotte finished the set up of a fully automated examination system of low alloy carbon steel piping girth welds for gas pipelines. This system used focalised probes and TOFD simultaneously. This system has been qualified by GDF (Gaz de France). The baptism of this system was about 30.000 welds on a pipeline in Morocco.

By the end of the nineties, a procedure was qualified for the examination of the Dissimilar Metal Welds (DMW) of PWR pressurisers for the Belgian utilities. This was performed, from the outside, using focussed TRL probes on a flawed full-scale mock-up of a 14" surge line nozzle to pressuriser DMW (figure 2). An ENIQ approach with technical justification was used for the smaller diameters (3", 4" and 6") of the pressuriser upper nozzles.

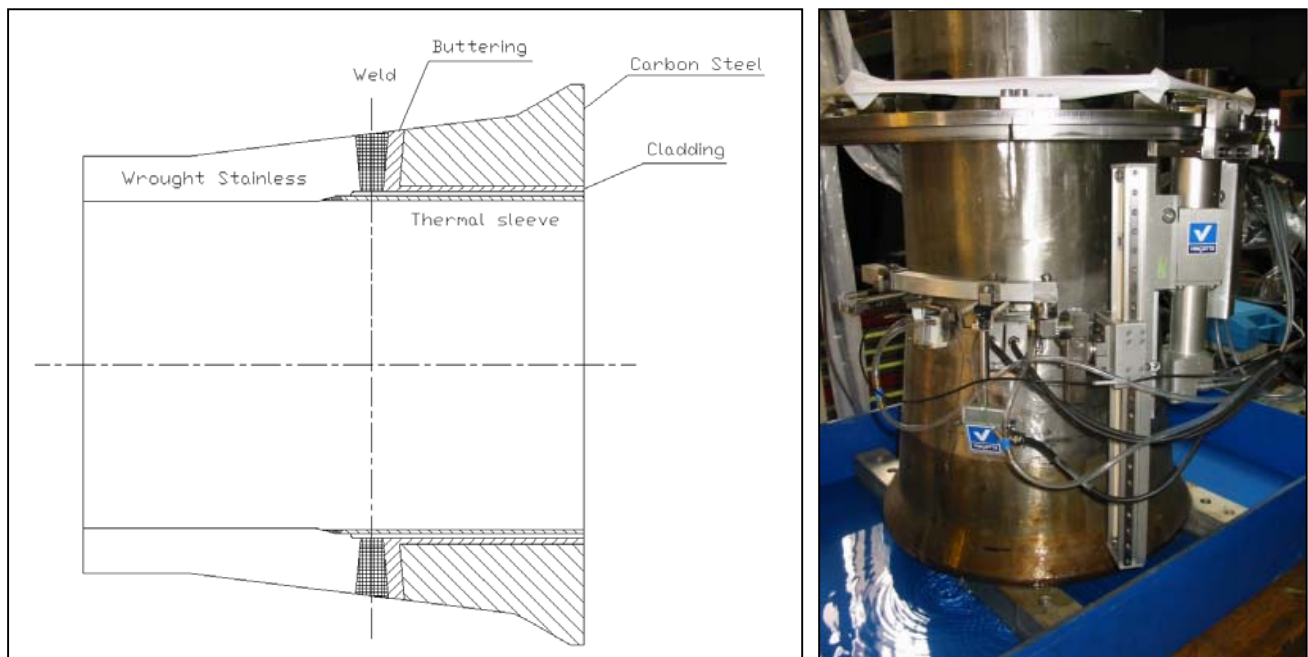


Figure 2

During the same period, a procedure for the examination of a PWR primary circuit stainless steel welds was developed. This procedure used large aperture focussed TRL probes, necessary for the examination of heavy wall stainless steel welds. This procedure was justified by the ENIQ approach based on the PISC results and laboratory work. This resulted in the examination of 14 welds in the nuclear power plant of Beznau (KKB), Switzerland. This was repeated in 2004.

ENTERING THE MILLENNIUM

Entering the millennium came together with phased array systems. As the demand to replace radiography by ultrasonic examination increased, Vinçotte developed procedures in accordance with the ASME BP&V Code, Case 2235 for the examination of vessel welds during their fabrication stage. The simultaneous generation of TOFD and shear wave angle beams using phased array probes was extensively used in these procedures. These procedures were qualified and witnessed by Lloyds representatives in various European countries. Over the years to follow, these procedures were updated each time the Code Case 2235 was revised.

Similar ultrasonic techniques were used to elaborate a procedure for the ISI of steam generator vessel welds. This was qualified for the Belgian utilities using an ENIQ approach. A few flawed samples were used to demonstrate the performance of the procedure and a technical justification was written to cover the full range of the procedure.

In 2000 Vinçotte needed to qualify a procedure for the examination of wrought to wrought stainless steel welds from a BWR recirculation piping system at KKL (Kernkraftwerk Leibstadt, Switzerland). This was to be done according to the PDI programme in the USA. Vinçotte sent a team to qualify the examination procedure at the EPRI centre (Electric Power Research Institute, Charlotte, USA). Many samples were scanned and after qualifying the procedure it was up to the team members to qualify as personnel qualification. The qualification process was witnessed by SVTI (Swiss Association for Technical Inspections) and HSK (Swiss Nuclear Safety Inspectorate). Personnel qualification being valid for three years, re-qualification has been done since then for all team members up to now.



Experience of examination of surge line DMW on pressurisers brought Vinçotte in 2003 again to KKB, Switzerland where a procedure was qualified on a 8" surge line DMW. Later on, other procedures were also qualified for the examination of wrought to wrought stainless steel surge line welds. These procedures used focussed TRL probes and were qualified on representative flawed specimens. The qualification process was organised by the utility and witnessed by SVTI (Swiss Association for Technical Inspections) and HSK (Swiss Nuclear Safety Inspectorate). As Vinçotte designs and fabricates their own phased array probes, it was only a matter of time to implement these probes in the procedures and qualifications. This was done also at KKB for the same type of welds using TRL phased array probes in 2007.

As mentioned in the previous paragraph, the design and fabrication of phased array probes [5] and the industrial use of ultrasonic phased array systems led to the start of a replacement programme. All mechanised procedures using conventional TRL probes for the examination of stainless steel components in the Belgian nuclear power plants were to be revised using TRL phased array probes. Lots of laboratory work and testing were done to establish new and updated procedures, mainly for the examination of DMW pressuriser welds and PWR primary circuit stainless steel welds. This work resulted in procedures qualified on a variety of flawed samples and using the ENIQ technical justification approach [6].

The extensive use and development of phased array probes led to the qualification of a procedure for the detection of cracks in a PWR primary circuit piping system. A stainless steel nozzle to primary pipe configuration had to be examined for the presence of thermally induced cracks. Examination was done by mechanically moving a large aperture TRL phased array probe on a saddle like surface around the nozzle (figure 4). The procedure was qualified according the EDF (Electricité de France) specifications.



Figure 4

THE LAST FEW YEARS

The growing interest of natural gas as source of energy increased the demand for transportation and storage systems. LNG is stored in cryogenic tanks made of 9% Ni alloy, welded with high Ni contents (60-70%). To replace radiography by ultrasonic examination, Vinçotte developed a procedure using phased array probes [7]. This procedure is in accordance with API620 appendix U. On different occasions this procedure was demonstrated and qualified on blind blocks to the satisfaction of the authorities. Since then, this procedure has been widely applied during construction of several gas terminal LNG tanks in Belgium, Canada and The Netherlands.

Not leaving all examinations to the power of the phased arrays, on demand of the French utilities (EDF), in 2006, a procedure for the examination of retaining rings (figure 5) had to be qualified on an open specimen. Using conventional probes, the procedure was developed on a retaining ring owned by Vinçotte containing a number of EDM (Electro Discharge Manufactured) notches. The final procedure performance was demonstrated on a retaining ring from EDF containing about 70 EDM notches placed in all imaginable orientations and places. The smallest EDM notches were (H x L) 0.5 x 6 mm and 1 x 2 mm. This procedure was successfully demonstrated and qualified in presence of the R&D people of EDF.



Figure 5

As the Belgian utilities were investigating the possibilities to replace some of the DMW from a pressuriser, a DMW examination procedure was requested. The replacement of 4" and 6" DMW was first planned and therefore, for each diameter, a welded coupon (figure 6a) was provided for the development of the examination procedure. EDM notches and side drilled holes were manufactured in these specimens. The procedures (ASME III and ASME XI) using TRL phased array probes, were demonstrated to the satisfaction of the authorities. These procedures were applied for the first time in March 2009 at the Tihange 3 unit (figure 6b).

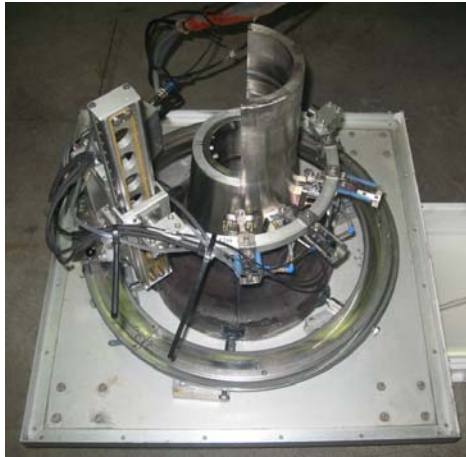


Figure 6a

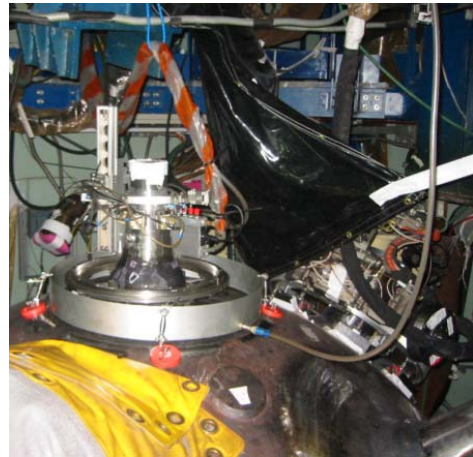


Figure 6b

Recently a procedure for the examination of SWOL (Structural Weld Overlay) was developed to be in accordance of the ASME Code Case N-740-2. A 14" DMW, 50mm thick surge line nozzle weld was overlayed by welding with a thickness of about 25 mm. EDM notches, side drilled holes and flat bottom holes were manufactured in the specimen. Dedicated use of TRL phased array probes made it possible to enhance the detection capability. The procedure was demonstrated to detect the tips of the notches in the volume to examine prescribed by the code. Finalisation of this qualification is ongoing (December 2009) and the procedure should be ready to apply in the Belgian nuclear power plants shortly.

CONCLUSIONS

As the demands on the NDT examinations varies by type or complexity, it is important for the NDT company to be flexible and able to develop procedures that satisfies the demands. It will take to long to list all qualification and validation activities that Vinçotte was involved in, but over viewing the previous paragraphs some common points were always present.

- ✓ Each qualification was performed with a dedicated team with a well-defined hierarchy, from project manager to mechanical scanner operator, all having the same goal in mind: a successful qualification.
- ✓ The selection of reliable dedicated equipment.
- ✓ Being sure that backup equipment and trained personnel were available at all stages of the qualifications.
- ✓ The development of detailed procedures for the acquisition and analysis of ultrasonic data.
- ✓ Dedicate training of personnel with a "failure is not an option" commitment.

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