ABSTRACT

The first French Evolutionary Pressurized Reactor (EPR) is being built on the site of LAMANVILLE. The French regulation of application imposes a rule to perform the Pre-Service Inspections on the components of the main primary system with qualified Non-Destructive systems. UT & ET inspection of CRDM Pressure Housing Welds enters this scope.

Qualification of both techniques is in progress at the present time, in order to end before PSI. This paper aims at presenting the technical solutions adopted to perform the inspection of 4 welds located all along housing. The lower weld is being controlled from OD, with UT examination process and the 3 upper welds are being controlled with ET examination process from ID.

Since there is no experience feedback of such examinations performed on current French PWR CRDM Pressure Housings, EDF has chosen to benefit from the technical experience of AREVA intelligeNDT, that had already performed ET examination on similar upper welds, on Konvoi units. Despite this experience, new technical solutions have had to be developed to perform the examination of the component, according to the specificities of FLA 3 EPR. AREVA Intercontrôle, for its part, is the supervisor of all qualification processes and the main interface with EDF, in order to ensure the respect of the specifications.

DESIGN OF EPR CRDM HOUSING

Regarding the choice of materials and type of welds, the design of EPR CRDM Housings is quite different from their design on current French PWR reactors, but very similar to housings on Konvoi reactors. On current French PWR reactors, all parts of CDRM Housings are made of austenitic stainless steel, linked together with screwed connections. On EPR and Konvoi reactors, housings are made of austenitic and martensitic stainless steel. Parts are linked together with 4 strength welds: 2 dissimilar welds (Alloy 82) and 2 homogeneous welds.

Furthermore, the main differences between Konvoi and EPR consist of:

- EPR housings are 5200mm long; 600mm longer than Konvoi housings
- On EPR, weld N°1/2 has been displaced 100mm away from the flange, in order to allow its examination on site, from OD, without dismantling, after pulling off the coils.
Figure 1 - EPR CRDM Pressure Housing - Final design

Figure 2 - EPR CRDM Pressure Housing – State for NDE

- EPR CRDM Pressure Housing
  
  - Consists of a martensitic latch housing connected via Diss. Welds to austenitic stabilized stainless steel parts.
  
  - Inner surface condition for latch housing, including region of weld 3/4 with $R_z \leq 6$ mm, upper section with $R_z \leq 10$ mm.
  
  - All welds are inside and outside machined, except root of weld 4/5. The root concavity is specified as less than 0,7mm.

- Sheet Steel Casing
- Operating Coil Assembly
- Drive Rod
- Position Indicator Coils
- Latch Unit
- CRDM Housing with Latch Unit State for NDE
- Sheet Steel Casing + Operating Coil assembly on CRDM Housing State for Operating
CONDITIONS OF INSPECTION

The examination of CRDM housings will be implemented as the RPV head lays on its set-down structure, located in a dedicated storage area in the reactor building, floor 24.1m.

The UT inspection manipulator for the examination of weld N°1/2 from OD will be introduced through the grid of the RPV Head lifting device (lvl 28.5m). Then, it will slide down along the housing until it reaches its final position, lying on the shoulder located up to the latch housing. The positioning of the UT manipulator over each of the 89 housings requires a dedicated handling device, as the polar crane cannot be used during inspection, except at the beginning and at the end of inspection. This autonomous handling device is called AAC (Autonomous Auxiliary Crane).

The ET examination of welds N°2/3, 3/4 and N°4/5 from ID will be done simultaneously to UT examination of weld N°1/2. The ET inspection manipulator will be introduced underneath the stored RPV head, through the door of the radiological protection.

Figure 3 - AAC (Autonomous Auxiliary Crane for UT inspection manipulator)

Figure 4 - UT inspection manipulator

Figure 5 - ET inspection manipulator
NDE & OPERATIONNAL SPECIFICATIONS

Only inner surface of welds is requested to be examined with a distance of 20mm from both sides of the WCL (Weld Center Lines). No particular defect is expected under normal conditions of temperature and pressure during operating, but NDE techniques must be able to detect longitudinal or circumferential flaws in dissimilar welds N°1/2 & 2/3 and only circumferential flaws in homogenous welds N°3/4 & 4/5.

During PSI, overall examination of 89 housings, including installation and removal has to be performed in less than 592 hours. UT examination of one weld N°1/2 (approx. 6 hours) and ET examination of welds N°2/3 to 4/5 (approx. 1 hour) are performed simultaneously.

UT EXAMINATION OF DISS. WELD N°1/2

For examination of the inner wall of weld N°1/2 from OD (only side accessible due to the presence of latch), IntelligeNDT has developed a brand new inspection manipulator to be implemented on EPR housings. Indeed, no such manipulator existed before, since this weld cannot be inspected in service, on Konvoi units, due to its position, being too close to the bolts which tighten the housing onto the flange.

In position for inspection, the UT manipulator lays on the shoulder located up to the latch housing. A passive break, closing under the weight of the manipulator and opening when lifting it, secures it in position during scanning.

The manipulator implements 4 conventional UT transducers, 3MHz, longitudinal wave. The angles of refraction are 64° for longitudinal direction of examination and 33° for circumferential direction of examination. Two crystals and a roof angle allow focusing of the beam at a depth of 12mm. A shaped wedge allows the transducers to perfectly follow the OD of the housings.

The coupling liquid is water, coming out from two inlets located on the sides of the transducers. A water loop system with pressurized air suction, added to a retaining ring, avoids leakage and allows coupling water to be re-cycled during inspection.
The 64° LW transducers (L30 x 130 x h15) are able to scan under bolts, on the OD, longitudinal direction of examination. No special geometrical limit is encountered with 33° LW Transducers, circumferential direction of examination. The Saphir + System is used for the acquisition and analysis of the data.
UT – CURRENT RESULTS

Qualification Process is in progress: Technical Justifications are being settled and tests have been implemented on realistic tests blocks with weld N°1/2, coming from OKILUOTO 3 housings spare parts.

Up to now, tests on blocks have shown that the UT process is able to cover the entire zone that must be examined. The tests have also shown that the UT process is able to detect longitudinal and circumferential notches (depth 5mm and aperture 0.2mm, various lengths) located in all materials (austenitic stainless steel, alloy 82 and martensitic stainless steel) with a SNR often better than 18dB. Nevertheless, the influence of the structure of the weld on the UT beam has to be studied with attention, in order to comfort the results.

More tests will occur in November 2010, in an environment representative of “on site conditions” and implementation of the UT inspection manipulator and cable handling of the AAC. These tests will be implemented to confirm the current results and to illustrate the performances on a larger scope of notches.

ET EXAMINATION OF DISS. WELD N°2/3 AND WELDS N°3/4 & 4/5

For examination of welds N°2/3 to 4/5, IntelligeNDT has proposed an inspection manipulator, implementing an ET probe from ID of the housing. This benefits from its experience feedback on Konvoi units where similar inspections are performed. The inspection manipulator (see fig. 9) is
equipped with MIZ80 for generating ET signals, and pushing the probe up to weld N°4/5 and pulling it backward.

The head of the probe includes 1 Pancake coil for localisation of welds and 1 +Point coil for detection of longitudinal and circumferential flaws. Their frequencies are respectively 100 KHz and 400 KHz.

**Fig. 9 - ET Manipulator**

**Figure 10 - ET Probe**

**ET – CURRENT RESULTS**

Qualification Process is in progress: Technical Justifications are being settled and tests have been implemented on realistic tests blocks with welds N°2/3, 3/4 & 4/5, coming from OKILUOTO 3 housings spare parts.

Up to now, tests on blocks have shown that the ET process is able to cover the entire zone that must be examined. They have also shown that + Point coil is able to detect longitudinal (only weld N°2/3 concerned) and circumferential notches (all welds) with depths from 0.5 to 3mm, lengths from 3 to 10mm and aperture 0.2mm. These results differ between materials and have to be analysed in detail, especially taking into account the influence of some important parameters, like for example, the root concavity of weld N°4/5, which is not machined on ID. Tests have also shown the Pancake coil is very efficient in detecting weld signal.
More tests will occur in November 2010 in an environment representative of “on site conditions” (vessel head partly represented with 3 CRDM housings) and implementation of the ET inspection manipulator, in its entirety. These tests will be implemented to confirm the current results and to illustrate the performances on a larger scope of notches.

CONCLUSIONS

Qualification of the inspection of CRDM Pressure Housing Welds with UT and ET is in process. More results will be available by the end of 2010 and will complete the Technical Justifications that are necessary to guaranty the confidence in the final performances. EDF and its contractors are doing everything possible to succeed in this challenge before the PSI of FLA3 EPR.

REFERENCES

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