UT capability and achievements of the MIS B 3G Equipment in the frame of hydrogen flaking detection, characterization and follow-up

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SUMMARY

1 – PRESENTATION OF THE INSPECTION TOOL
2 – HYDROGEN FLAKES HISTORY
3 – INSPECTION TECHNIQUE AND RESULTS
4 – HF REPEAT AND SUPPLEMENTARY INSPECTIONS
5 – ANALYSIS PROCESS
6 – RESULTS REPRODUCIBILITY
6 – CONCLUSION
The MIS B 3G manipulator is compliant to be able to inspect Belgium three different RPV designs:

- Doel 1 & 2 350 MWe (Westinghouse)
- Doel 3 and Tihange 1 & 2 900 MWe (Framatome)
- Doel 4 and Tihange 3 900 MWe (Westinghouse)

The inspection code to be applied is the ASME code with specific additions by the utility.
2 – HYDROGEN FLAKES HISTORY

History: During DOEL3 ISI30 2012 atypical indications have been detected.

Belt line Probe Array:
- 4 transducers L63°
- 1 transducer L0° (Synchronisation, cladding thickness measurement)

Belt line examination:
- 25 millimetres from the inner surface of the vessel
- Component thickness = 200mm

Subsequently, an inspection technique (based on the shell welds examination procedure and already available probes) have been applied in Doel 3 and Tihange 2 in 2012 and led to the discovery of around 8000 and 2000 indications.
3 - HF INSPECTION TECHNIQUE

- Full thickness of the shell (200 mm) is inspected using a combination of probes used for Belt line and shell welds inspection.

- Main analysis done with L0° probes data and completed with shear wave 45° probes in four directions.

![Diagram showing inspection technique and images of Platine V12T and Platine V3T.]
3 - HF INSPECTION TECHNIQUE

Shell inspection tool:

- It carries both Shell to Shell welds and Belt Line examination UT transducers (detection and sizing of underclad cracks) implemented for the first time in Belgium at DOEL 3 ISI 30.
Subsequently to these two inspections results a safety case have been raised by ELECTRABEL and has been able to identify these indications as Hydrogen Flakes (HF). Intercontrôle, was among others, a key partner of this safety case for both inspection technique qualification and inspections to be performed.

The performances requested for these inspections in order to evaluate and follow-up these indications were:

- High sizing accuracy (allowed by use of sharply focused probes and precise positioning of the scanner),
- High reliability and reproducibility of the MIS B 3G UT technique (which have been lately demonstrated by the repeat examination performed in 2013 and 2014 for both Doel 3 et TIHANGE 2 units),
- Associated advance data analysis software CIVACUVE to perform sizing and ease the follow up of indications.
4 - SUPPLEMENTARY INSPECTIONS

- Nine inspections for HF detection or follow up:
  - DOEL 3 (July 2012) : first detection of « HF »
    - ~ 8400 indications
  - TIHANGE 2 (September 2012) : Second detection of HF
    - ~ 2000 indications
  - TIHANGE 1 & 3 (2013) : None

- Inspections for qualification dossier building in order to restart the Plants (Comparison of results before and after pressure test):
  - TIHANGE 2 (2013) : no evolution,

- Inspection done with the qualified inspection technique:
  - TIHANGE 2 (2014) : no evolution -> but more 3000 indications,
  - DOEL 3 (2014) : no evolution -> but more than 13000 indications,
  - DOEL 1, 2 & 4 (2015), Tihange 1 (2016) : None

- DOEL 3 and TIHANGE 2 back in operation at the end of 2015
  - Next inspections to be performed in 2016 and 2017
5 - MAIN CHALLENGES

In DOEL 3 and TIHANGE 2 more than 13000 and 3000 indications are respectively reported.

► The main challenge is to deliver the examination results in an reasonably acceptable duration for the utility. This challenge is achieved thanks to both CIVACUVE (UT data analysis software) and data analysis team organization.

► The designed concept of CIVACUVE is to provide the users numerous tools to help the operators along the data analysis steps. These steps and associated tools are described in the following slides.
First CIVACUVE processed raw data to position indications in the inspected component coordinates. Then it applies a « segmentation » algorithm for each probe. This algorithm is designed to consider only data representative of the expected defect.

The parameters allowing such raw data processing are previously defined by specific technical justification and validated on representative mocks-up (these parameters take into account information such as probe characteristics, scanning mode, UT instrument sampling mode, expected defect characteristics …). These parameters are part of the qualification process and defined in the inspection procedure.

The output of this fully automated data processing is a list of « contours » which main characteristics (as position, amplitude, envelope in coordinate X, Y, Z, …) are available and stored in a data base.
Next analysis step is to select, among these « contours », which is representative of a defect. For this purpose, CIVACUVE offers different tools such as:

- Standard UT views and zoom (ASCAN, BSCAN, CSCAN, DSCAN) superposed with weld or component geometry information. These views allows to superpose from one to eight different probes data including from successive inspections to help indications follow-up (see later slide),

- « Contours » selection tools based upon a combination of various criterion (amplitude, location X,Y,Z, size of « contours » envelopes). This allows to select the relevant contours to be further analysed

- Reporting tools allowing to create examination report by adding « contours » to a report which secures the reporting of indications

- Various sizing tools (among them one specifically developed during the qualification for the HF sizing taking in account the non homogenous reflectivity of such defects).

- Possibility to export reported data in for example « Excel » format in order to performed indications follow-up easily
5 – ANALYSIS PROCESS

Main advantages are the following:

- Data processing with qualified parameters warranties the reproducibility of data UT analysis thus the quality of the examination results is much reliable thanks to qualified procedure and automated processing,
- The part of human factor in data analysis quality is highly reduced by using advanced data analysis software,
- Data processing is much quicker than a standard analysis on RF raw data performed by an operator,
- The assessment about potential defect evolution is much easier with advanced tools,
- When confronted with a high number of defect as in the Belgium HF case, it is remains possible to deliver results in an acceptable duration for the utility which seems unlikely with standard UT data analysis software.
6 - RESULTS REPRODUCTIBILITY

- Example of data superposition (CSCAN) between two successive inspections (DOEL 2012/2013)
6 - RESULTS REPRODUCTIBILITY

Example of reproducibility results for transducer 1L0° 30-100 mm
7 – CONCLUSION

Since 2012, the field feedback of RPV inspection in Belgium shows that confronted to an unknown challenge in terms of number of indications to detect, to characterize and to follow-up, the MIS 3G concept has demonstrated its reliability and flexibility to address such phenomenon. Our proposed solutions have been effective and fully met the utility’s expectations.

In addition, it should be highlighted that these achievements would not have been possible without the excellent partnership and communication within the whole team involved in the safety case instructed by the utility.
THANKS FOR YOUR ATTENTION

QUESTIONS ??