Pipeline Girth Welds Inspection Using Automated Ultrasonic Testing (AUT) with Zonal Discrimination – Simulation of POD Curves Using CIVA Software

Bastien CHAPUIS *, Giuseppe DI CRISCI **, John HAMILTON **, Frédéric JENSON *, Laurent POMIÉ **
* Commissariat à l'Energie Atomique (CEA) LIST, Gif-sur-Yvette, France
** Technip

Abstract

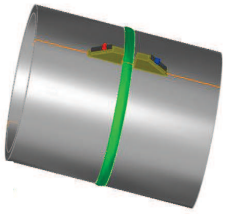
The inspection of pipeline girth welds can be performed by automated ultrasonic testing systems composed of several channels (different transducers or multi-element probes with a set of different focal laws). These systems allow, with a single scan along the circumference of the pipe, a complete examination of the weld using the zonal discrimination approach. However, the use of these systems is subjected to the demonstration of their performances confronted to realistic degradations of their environment. This demonstration is synthesized in a qualification dossier and is supported by experimental sensitivity analysis to several influencing factors (pipe temperature, error in the positioning of the sensors…) and POD curves determination. This requires a large amount of experiments.

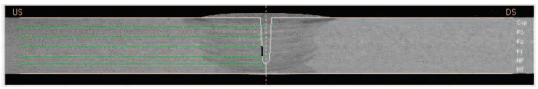
In order to reduce the cost and time required today to determine a POD curve for a given inspection method simulation can be used.

Simulations of typical girth welds inspection configurations using CIVA software are performed. Many influencing factors can be taken into account in CIVA such as the material and geometry of the specimen, the location, orientation and geometry of the flaw, the orientation and the position of the probe compared to the weld and the pipe temperature. Uncertainty propagation is performed using a Monte Carlo sampling strategy to get POD curves. In accordance to the DNV recommended practices a cumulative lognormal distribution is used to approximate POD curves based on Hit/Miss data. Purely numerical POD curves can therefore be obtained for a single channel and for the global inspection system. The whole computation scheme to get the numerical POD curves using CIVA software and its dedicated POD module is presented.

Pipeline Girth Welds Inspection Using Automated Ultrasonic Testing (AUT) with Zonal Discrimination – Simulation of POD Curves Using CIVA Software

Bastien CHAPUIS(1), Giuseppe DI CRISCI(2), John HAMILTON(2), Frédéric JENSON(1), Laurent POMIÉ(2)
(1) **CEA LIST**, Gif-sur-Yvette, France
(2) **Technip**

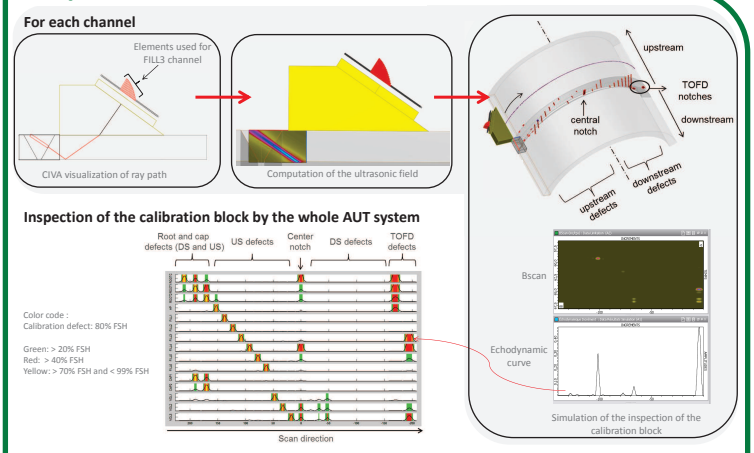




Context

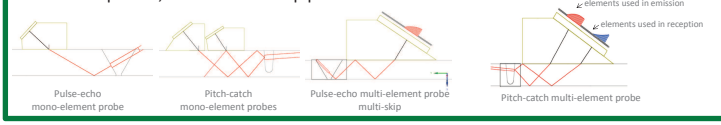
- A girth weld is the assembly of two pipelines for a subsea flowline
- As required by regulations (e.g. DNV-OS-F101 [1]) such welds have to be verified for integrity, the full volume of the weld must be inspected and flaw size shall be characterized
- Automated Ultrasonic Testing (AUT) systems generate and propagate ultrasounds waves thanks to different mono-element transducers or a phased array transducers with different focal laws. Each transducer or focal law (= a channel) is dedicated to the inspection of a specific zone of the weld → zonal discrimination [2]
- The qualification of the system requires the demonstration of performance through the determination of a POD curve, which is a process long and costly and necessary for each modification of the inspection procedure (pipe thickness, weld geometry, …)→ interest for simulation

Inspection of calibration blocks



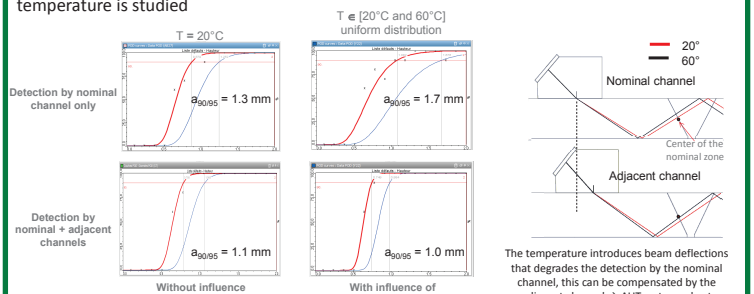
→ Verification of the correct description of the configurations into CIVA
→ Calibration of amplitude threshold for the different channels [5,6]

- Different probes, weld bevels and pipe thicknesses simulated:



Example of results

- In this example a POD curve is determined for one channel, the influence of the pipe temperature is studied



- The temperature degrades the detection by the nominal channel, but the performances of the whole system are maintained

Applications - Perspectives

Possible applications:

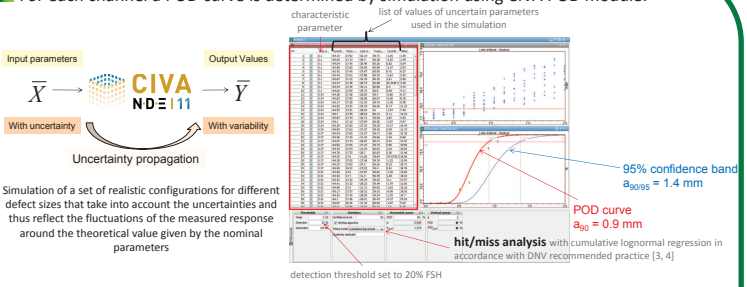
- Optimize the design of experiments: select the manufactured defects in order to focus on the range of interest of the POD curve (reduce number of tests in ranges where POD = 0 or 1)
- Quantify the impact of an uncertain parameter not taken into account in an existing experimental POD curve
- Identify the uncertain parameters to better control to bring back an experimental POD curve to an acceptable value
- Provide technical justifications when minor changes of the procedure are carried out in order to avoid a new experimental campaign

Perspectives

- Simulation of Probability of Rejection (POR) curves, requires defect sizing algorithm
- Redaction of a "Best Recommended Practice" document in the framework of IIW for the use of simulation for UT inspection of welds
- Bayesian fusion of empirical/simulated data to increase reliability of POD curves and limit the number of experiments

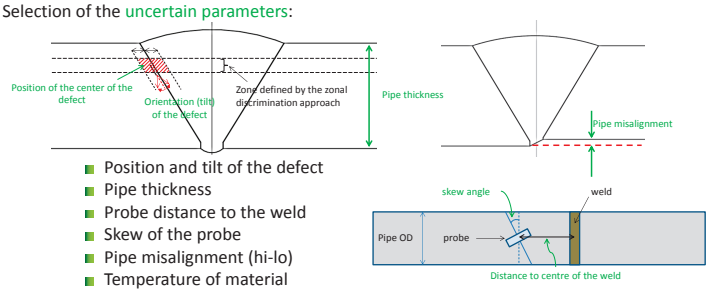
POD curves determination

- For each channel a POD curve is determined by simulation using CIVA POD module:



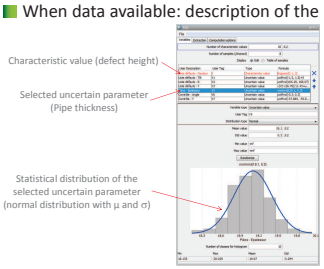
Simulation of a set of realistic configurations for different defect sizes that take into account the uncertainties and thus reflect the fluctuations of the measured response around the theoretical value given by the nominal parameters

- Selection of the uncertain parameters:



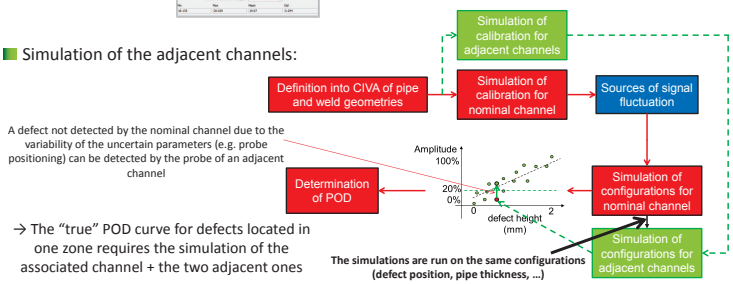
- Position and tilt of the defect
- Pipe thickness
- Probe distance to the weld
- Skew of the probe
- Pipe misalignment (hi-lo)
- Temperature of material

- When data available: description of the uncertainty with real statistical distributions:



Otherwise use of tolerances given in the inspection procedure + uniform distribution

- Simulation of the adjacent channels:



→ The "true" POD curve for defects located in one zone requires the simulation of the associated channel + the two adjacent ones

References

1. DNV-OS-F101, *Submarine pipeline systems*, Appendix E "Automatic ultrasonic girth weld testing", 2010
2. ASTM E1961-11, *Standard Practice for Mechanized Ultrasonic Testing of Girth Welds Using Zonal Discrimination with Focused Search Units*, 2011
3. NordTest Technical Report 394, *Guidelines for NDE reliability determination and description*, 1998
4. DNV-RP-F118, *Pipe girth weld AUT system qualification and project specific procedure validation*, 2010
5. E. Ginzel, D. Stewart, *CIVA Modelling for Pipeline Zonal Discrimination*, NDT.net, 2011
6. F. Foucher, P. Dubois, V. Gaffard, H. Godinot, H. Romazzotti, A. Courbot, E. Schumacher, Validation of the simulation of pipeline girth welds PA UT inspections, *Proceedings of the ASNT Fall Conference*, 2012

bastien.chapuis@cea.fr