DNV Guidelines on AUT Qualification for Girth Weld Inspection during Offshore Pipelaying

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Abstract. AUT has gained a position as an increasingly important NDT-method for offshore pipelaying projects over the last years. Due to the possible influence on the AUT reliability of project specific parameters like weld bevel configuration, material and typical occurring defects, the DNV Offshore Standard F101 for offshore submarine pipelines calls for a qualification of the AUT system prior to pipelaying. A system is regarded qualified if it can be shown that the largest acceptable defect height has a Probability of Detection (PoD) of 90% at a 95% confidence level. The code does not outline how this criterion can be met. DNV has now prepared a recommended practice (RP) on guidelines for pipe girth weld AUT qualification in order to clarify what is intended to be included in a DNV AUT qualification. Beside describing a reasonable way to comply with the qualification requirements, the guidelines are intended to provide a common and fair basis for qualification of the different AUT systems present for different applications. This paper will contain an introduction to the RP and we will share our experience with it so far.
Motivation

- DNV Inspection Technology group in Stavanger responsible for NDE reliability evaluation within DNV
- DNV OS-F101, Offshore Pipeline Standard: Qualification required if Automated Ultrasonic Testing (AUT) is used for pipeline girth weld inspection during production
- Important requirements of qualification, DNV OS-F101 App. E:
  - Smallest allowable defect height in acceptance criteria shall have a documented detection of 90% POD at a 95% confidence level
  - Under sizing tolerances giving less than 5% probability of under sizing shall be established
  - Eventually, criterion of 85% POR at a 95% confidence level can be applied
  - Repeatability test, repeated scans of calibration block shall show amplitude variations within ± 2dB
  - Temperature sensitivity test, repeated scans shall show amplitude variations within ± 2dB
  - Guidance band offset tests
Motivation

- It is not clear for the users how these (and the other) requirements can be met
  - How to perform the different trials?
  - What is needed in order to get the 90%|95% defect height?
  - Apparently inconsistent scope of AUT qualification among different applications

- The upcoming DNV Recommended Practice: Guidelines for Pipe Girth Weld AUT Qualification is intended to provide a clear and consistent scope of AUT qualification

AUT Particulars

- Fixed or Phased array ultrasonic systems
- Zonal Pulse-Echo (PE) channels
  - Calibration against FBHs (usually 2 or 3 mm Ø set to 80% FSH) and notches
  - Sensitivity setting by specifying a detection/reporting threshold (% of FSH)
- TOFD (Time-Of-Flight-Diffraction)
- Volumetric / mapping channels
- Use of information varies among the different channel types
  - Detection based on PE only, or PE and TOFD/volumetric channels
  - Height sizing algorithms: Amplitude response from defects calculated into defect heights

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AUT Qualification

- Qualification of AUT systems is done to:
  - Document sufficient detectability of non-allowable defect sizes
  - Determine defect sizing errors
  - Show fulfillment of operational requirements
  - Show adequacy of AUT quality assurance system
- In particular attributed to ECA based defect size acceptance criteria
- A qualification is in principle project/task specific, i.e. material, thickness, weld method, bevel geometry specific
- Detection data from a sufficiently high number of relevant defects required in qualification trials to obtain sufficient confidence in the results

Qualification Steps

- Evaluation of documentation and available historical reliability data/information
- Planning and execution of reliability trials and operational tests
- Reference investigations
- Evaluation of results from the reliability trials and operational tests
DNV RP Guidelines

Guidelines for:
- Requirements on welding of test welds
- How to perform repeatability tests on calibration blocks
- How to perform temperature trials
- How to perform reliability tests
- Types and number of defects required for POD analysis
- How to perform destructive reference testing
- Requirements for analysis of the collected data

DNV RP Table of Contents

1 INTRODUCTION
   1.1 Scope
   1.2 Objective
   1.3 References
   1.4 Acronyms and Definitions

2 QUALIFICATION PROGRAM
   2.1 General
   2.2 Extent of Qualification Program
   2.3 FULL QUALIFICATION PROGRAM
   2.4 QUALIFICATION VARIABLES

3 TEST WELDS
   3.1 General
   3.2 Requirements to test weld
     3.2.1 Welding of test welds
     3.2.2 Types and number of defects

4 QUALIFICATION TESTING
   4.1 Repeatability test programme
   4.2 Temperature sensitivity test programme
   4.3 Reliability test programme

5 VALIDATION TESTING
   5.1 General
     5.1.1 Qualification criteria
     5.1.2 Supplementary NDT of test welds
     5.1.3 Extent of weld cross sectioning
     5.1.4 Marking of test specimens
     5.1.5 Salami cross sectioning

6 ANALYSIS OF DATA
   6.1 GENERAL
     6.1.1 Repeatability test programme
     6.1.2 Temperature sensitivity test programme
     6.1.3 Reliability test programme
     6.1.4 Evaluation of detection and sizing ability

7 VALIDITY OF QUALIFICATION
   7.1 Operational Range Validity
   7.2 Validity Time

8 CERTIFICATE OF QUALIFICATION

9 REFERENCES
DNV RP Requirements Repeatability

- On calibration bloc: 10 consecutive scans in each of the positions:
  - 5G 12 o’clock,
  - 5G 6 o’clock,
  - 6G and 2G

- Amplitude response for each reflector shall vary less than ± 2dB between the scans

DNV RP Requirements Temperature Tests

- In total 30 subsequent scans at 90°C elevated temperature
- Time between each scan as short as possible, not more than 5 minutes
- Pipe diameter do influence heat build-up on transducer
AUT Reliability Test Scans

- Each weld scanned twice, CW and CCW
- Positions on welds for macro sectioning chosen with available information from reliability test scans and info from supplementary RT
- Markup for macro sectioning, positions found with AUT scanner
- Eventually, welds prepared for and subject to Immersion Ultrasonic Testing
- Macro sectioning after Immersion Ultrasonic Testing, min. 3 macros each position

POD Reliability Analysis

- Review macros
- Tabulate and collect data of defect position, length, AUT and macro depth and height sizing, AUT amplitude, transverse location, zone, type
POD Analysis

- Binary regression, according to Nordtest Technical Report 394 (04-1998): Guidelines for NDE Reliability Determination and Description

\[
POD(x; x_0, \beta) = \frac{1}{1 + \left( \frac{x}{x_0} \right)^\beta}
\]

- Hit/miss of weld defects depend on applied reporting threshold

- Some considerations:
  - Include all defects, or disregard short defects
  - Might be different detectability in different channels, i.e. surface (due to calibration) and volumetric
  - TOFD

POD Analysis

- 90%-95%-defect size is the main result from the POD-analysis

- RP requirement: Show POD as a function of height and position in weld (root, fill, cap)
Height Sizing Accuracy

- Height sizing error = AUT height – Macro height
- Negative height sizing error means under-sizing
- Lower 95% percentile evaluated from results

Some Important Issues Covered by RP

- Some disregarded defects needs to be within the data material, in order to be able to estimate a POD curve
- Data needs to cover all types of defects from the different zones sufficiently
- Avoid stacked defects for macro positions
- Variables important for AUT reliability will be identified, conditions at trials as close as possible to field work
Conclusions

- Main conclusion: Requirements in DNV OS-F101 fulfilled when DNV RP on AUT qualification is used
- Still draft version, some few issues still to be sorted out
- Feedback so far:
  - Unnecessary comprehensive for some applications

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