Presentation of a system for AUT on Pipelines and Penstock
THE PIPERUNNER

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SUMMARY

- About our companies
- What is AUT
- Summary of NDT method
- Codes and standards
- History and development of the systems
- Qualification stage of the system
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- Conclusion
ABOUT MISTRAS GROUP
and
EDF DTG
MISTRAS GROUP

- Established in 1968
- 13 sites in France ( + implanting worldwide)
- 400 agents in France ( 5000 worldwide)
- Missions:
  - Systems and services provider
  - NDT
  - Software, Hardware
  - Products and systems
  - Training
MISTRAS GROUP
EDF DTG
(Direction Technique Générale)

- Established in 1946
- 5 sites in France
- 650 agents
- Missions:
  - Ensure the safety of the exploitation and the quality of new hydraulic components
  - Guarantee the performance and optimization of power generation
  - Ensure respect for the environment
WHAT IS AUT?
What is AUT?:

AUT : Automated Ultrasonic Testing

- Ultrasonic testing fully automatic
- Requiring a fixed guide and a motorized advance
- Using combinations of several methods Ultrasonics (TOFD, Pulse Echo, Phased Array …)
Benefit of AUT:

- Significant reduction of testing duration (testing 1 in single acquisition)
- Instant results
- Reproductibility of testing (low influence of the operator)
- Increased probability of detection
- Accurate positioning and sizing of indications allowing monitoring over time
- Used in lieu of radiography (no radiation allowing coactivity on site) and allow to reduce the amount of RT during the complete manufacturing process.
SUMMARY OF NDT METHOD
TOFD
(Time of Flight Diffraction)

TOFD method of ultrasonic inspection is a very sensitive and accurate method for non destructive testing of welds for defects. TOFD is a computerized system that was invented in the UK in the 1970s for the nuclear industry by Dr. Maurice Silk. The use of TOFD enabled crack sizes to be measured accurately.
TECHNICAL PRINCIPLE
PHASED ARRAY

PA (Phased array) is an advanced method of Ultrasonic that has applications in industrial NDT, originally pioneered by Albert Macoyski of Stanford University.
The movement of the acoustic beam is formed along the axis by electronic excitation, without any mechanical movement.
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<tr>
<th>Straight beam</th>
<th>Angle beam</th>
<th>Focused straight beam</th>
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CODES AND STANDARDS
PHASED ARRAY:
- NF EN ISO 13588: Used of automated phased array technology

TOFD:
- NF EN 583-6: Time of flight diffraction technique as a method for detection and sizing of discontinuities
- NF EN ISO 10863: Use of time of flight diffraction technique (TOFD)
- NF EN ISO 15626: Acceptance criteria for the time of flight diffraction inspection technique
AUT :

-CPC IH.X.DT.10033 (EDF) : Specification of common requirements + specification for the validation of "AUT TOFD" system and RRC-MH 3rd edition

-SG-DIS-PNE-C-003 (GRT GAZ): General specification for the technical qualification of an automated control system for ultrasonic examination of girth welds on site.
HISTORY AND DEVELOPMENT OF THE SYSTEMS
The first AUT system called PIPERUNER designed by EUROSONIC (a MISTRAS GROUP company) in 2008 was qualified by GRTGAZ to be used on gas pipelines girth welds.

The combinaison of TOFD and Pulse Echo were used.

- Two probes (TOFD) for welded volume + HAZ
- Two probes (PE) for the root (dead zone of TOFD)
- Two probes (PE) for the cap (dead zone of TOFD)
- Four probes (PE) for transverse indication

TOTAL: 10 probes
PIPERUNNER « first evolution »
During this time, an evolution of the RRC-MH edited by EDF allow the AUT to replace RT technique during the fabrication of penstocks.

After several test we find that the piperunner is not suitable for use in mountain conditions like:
- Low temperatures
- High slopes (more than 60 °)
- Hard access

THE PIPERUNNER MUST EVOLVE
Evolution of the new Piperunner: In 2011 the new Piperunner is born.
Mechanical evolution:

- Length: 450 mm instead of 600 mm
- Width: 300 mm instead of 600 mm
- Height: 250 mm instead of 350 mm
- Weight: 10 kg instead of 23 kg
Evolution of the control unit:

- Length: 250 mm instead of 500 mm
- Width: 160 mm instead of 500 mm
- Height: 80 mm instead of 500 mm
- Weight: 3 kg instead of 10 kg
- Power supply: Batteries instead of AC power
Ultrasonic evolutions:

The main evolution is the replacement of 4 pulse echo probes by 2 phased probes: this allow to reduce the quantity of UT probes necessary to guarantee 100% covered area.
Ultrasonic evolutions:
QUALIFICATION STAGE OF THE SYSTEMS ACCORDING EDF SPECIFICATIONS
The qualification is performed on a calibration block (described hereafter) The block is representative with the same welding process, and with several reflectors located in representative positions (volume, root, cap, HAZ) and representative orientations; The experimental approach is completed with a simulation step in order to check:
- The full covered areas with both techniques
- The influence of parameters (variation of the bevel angle, specific geometrical shape)
- The size and position of defects not included in the reference block (defects in HAZ, LOF, …)
Results of CIVA TOFD simulation (with and without lateral Wave and backwall echo): no detected defects in dead TOFD zones
Results of CIVA PA simulation (LOF)

Cap PA examination configuration
All reflectors must be detected and correctly measured (position, length, depth)
Coupling have to be proved during the full acquisitions for TOFD probe and with
specific PA focal law.
IMPLEMENTATION ON SITE
Pictures of real conditions

High slopes
Hard acces to the weld
Pictures of real conditions

Low space between the pipe and the floor
Pictures of real conditions

Low temperature (snow conditions)

Wet conditions
Movie 1
FINAL RESULTS
Each channel can be analysed independently

Phased Array
FINAL RESULTS
Each channel can be analysed independently

TOFD
FINAL RESULTS
Each channel can be analysed independently

Coupling
AUT-TOFD with additional PA proved to be a good and reliable solution to reduce the part of RT during the manufacturing process,
adapted development was necessary to suit the real conditions of the work,
steps of qualification were necessary to prove the capability of the systems regarding NDT performances and implementation,
simulation help to reduce the quantity of mock-ups necessary for the qualification,
AUT-TOFD with additional PA is now a EDF standard (RRC-MH) for the NDT during the penstock manufacturing and construction work (new/new welds examination),
however RT is still necessary for particular conditions such as new/old welding examination.
THANK YOU FOR YOUR ATTENTION

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