Controlling the risk due to the use of gamma sources for NDT First feedback from the deployment of replacement NDT Techniques

GOUVERNANCE DIRECTION | ORGANISATION PROFESSIONNELLE | CERTIFICATION ET QUALIFICATION | SCIENTIFIQUE ET TECHNIQUE | ÉVÉNEMENTIEL ET COMMUNICATION

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The context

- In France, two regulatory bodies rule over the activities using gamma ray sources
  - Public Health
  - Nuclear Safety
- Due to unacceptable accidents, in 2005, the French Nuclear Safety Authority decided to work with industrial companies using gamma radiography on two topics related to this field:
  - Development and optimization of best practices during radiographic inspection,
  - Identification of replacement methods to radiographic testing

The project was coordinated by COFREND (French Confederation for Non-Destructive Testing)

Maintenance Policy

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Question 1: Why not start by considering the purpose of the inspection, as part of a maintenance policy ?

- Nondestructive evaluation (NDE) plays a key role in managing material aging, identifying degraded components in a timely manner
- Utilities chose, by voluntarism commitment, to reduce, when technically possible, the recourse to radiographic techniques

Question 2 : Why use RT today ?

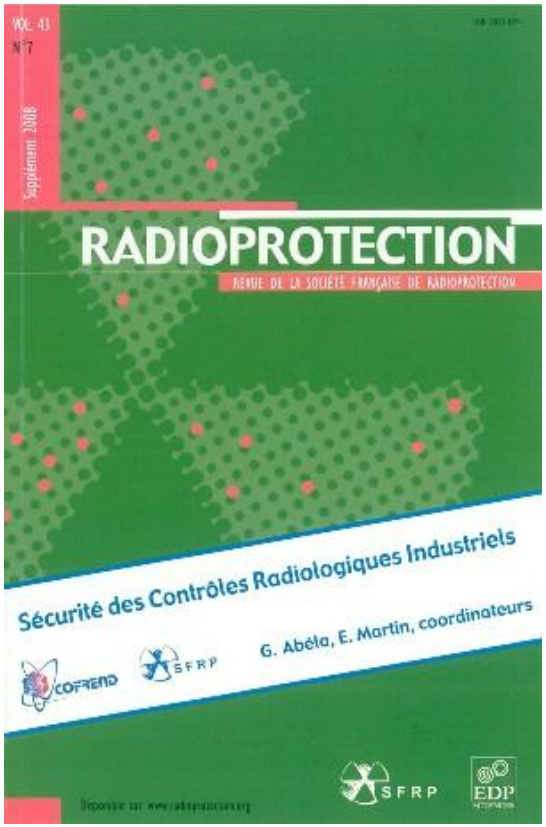
- To conform to local or international codes and standards, with their acceptance criteria, for the production of components
- Gamma-ray sources are easy to use : easy access to Plant areas, no need for external power source
- The historical NDT performed on the pre-service inspection is still in use: easy to compare radiograps between different inspections
- Radiography is often the most effective NDT, depending on the purpose of the inspection.

Best Practices

A working group including COFREND and the French Society for Radioprotection (SFRP) organised 9 workshops within objective to propose doing Recommended Practices on Responsibilities, Equipment, Training, …..

The delivery :

- Set-up a guide to operators for self- evaluation, taking into account the human factor and the conditions of work of the personnel involved in radiography.
- Specific beaconing
- Specific carriage
- Storage



Alternative methods (1/3)

In addition to providing guidance in the use of best practices for RT, several projects were focussed on the investigation of replacement methods:

- COFREND analysed the purpose of the inspections and proposed guidelines enabling to replace gamma radiography or, if need be, to justify its use.
- Collaborative projects covering a wider field of investigation, including the evaluation of advanced techniques were launched

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Recommanded Practice to determine the choice of the NDT

A Step by Step questionnaire help to define the specifications :

- Objectives of the inspection
  - Stage, codes, extent, requirements in detection, sizing, localisation
- Parameters of the zone to be inspected
  - Manufacturing mode, material, geometry, surface condition
- Parameters of the inspection environment
  - Accessibility, inspection conditions
- Parameters of the flaw
  - Dimensions, type, orientation, localisation, features, nature

A lax definition of the inspection requirements could lead to an inadequate inspection thus breaking the transition to others techniques

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Collaborative projects

Collaborative projects have been launched since 2005 with special interest in advanced technologies. They explored tracks that could be relevant to the problem.

The objectives of these projects were:

- to identify credible alternatives to industrial radiography using Ir 192 to decrease significantly operational dosimetry of inspection personnel

The key steps of the projects were as follows:

- Use state-of-the-art non-destructive testing techniques, specifically applicable to welds, and identify their advantages / disadvantages and limitations
- Reach a consensus of the participants at the end of the embodiment of the prior art on the selection of the techniques to be experimented

Where we Are ? Deployments are in progress (1/4)

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Difficulties in deployment

Replacing a NDT method/technique with another…..

UT has great potential to be used in lieu of RT, but History shows that the combined use of RT for fabrication exams followed by the use of UT for pre-service and in service exams underlines the difficulties to follow some defects because the same physical phenomena are not used

Due to the physical principle of UT and RT, the performances of these two methods cannot be the same, even though they inspect the volume of the component.

Radiography testing	Ultrasonic testing
Interaction of a high energy electromagnetic wave with the atoms of the structure under test.	Interaction of acoustic waves with discontinuities in the material.

Where we Are ? Deployments are in progress (2/4)

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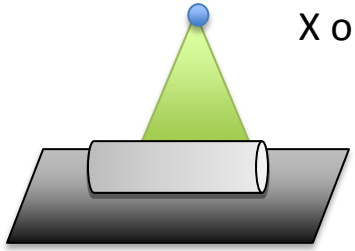
EVALUATION OF THE PERFORMANCE OF CR SYSTEMS WITH DIFFERENT SOURCES

CONVENTIONAL RADIOGRAPHY



X or γ source

object
film

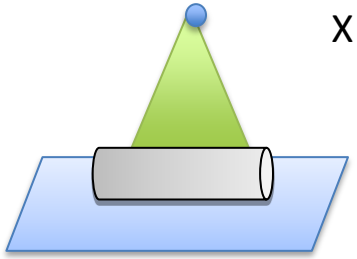
$$AgX \xrightarrow{irradiation} AgX + Ag^{+}$$

(Latent image)

Chemical development

Final image

COMPUTED RADIOGRAPHY



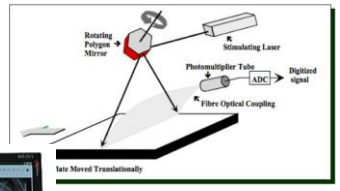
X or γ source

object
imaging plate (IP)

Electron/hole traps

(Latent image)

Collection of PSL
(photo-stimulated-luminescence)
via laser scanning



Final image

The objectives were to assess the advantages of CR/DR versus conventional film (Exposition time, Energy, ..)
First of all the Image Quality accordingly to ISO 17636-2, RCCM 2007, and ASME V-2010 with different IQI

- **Existing discrepancies between the different standards may cause non negligible difficulties in the process of introducing CR.**
- **Harmonization between these standards and codes would certainly benefit manufacturers, in enabling them to fulfil all requirements and end-users.**

Where we Are ? Deployments are in progress (3/4)

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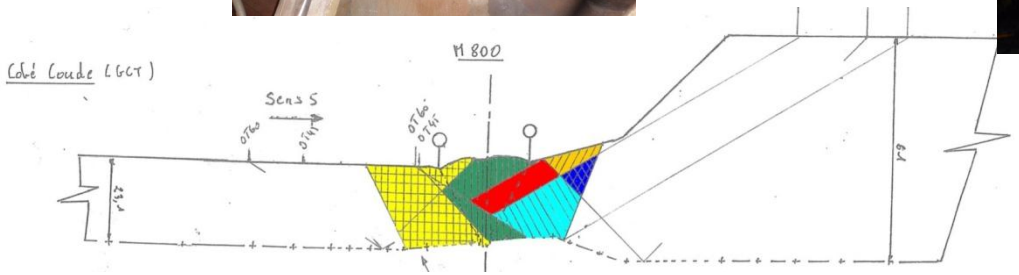
Conventional UT : Difficulties encountered

- **The surface condition of the welds created difficulties for inspections**
  - Unexplorable zones were found
  - The profile of the welds does not always allow the use of conventional probes
- **The collective dose on site was higher than predicted**
  - The time taken to inspect the welds was sometimes longer for UT than RT
  - The inspections have to be moved in the outage schedules in order to reduce the dose of the operators
- **The UT inspections were sensitive to geometric echoes**



Where we Are ? Deployments are in progress (4/4)

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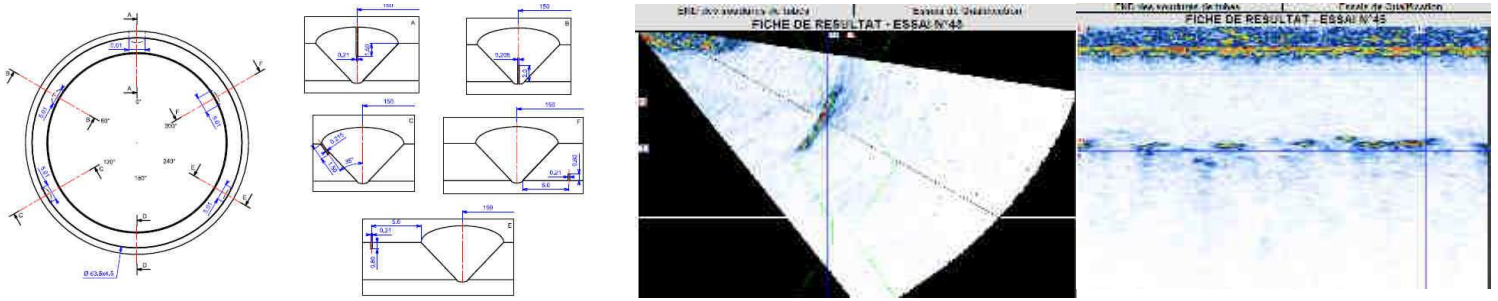
Use of combined UT Advanced Techniques in lieu of Conventional UT associated to Radiography : Difficulties encountered

Questions:

- How to evaluate the feasibility of RT replacement by UT?
- How to start with manageable efforts?
- Which process design should be used?
- What are the chances of a qualification?

Regarding codification requirements: [RT + UT] cannot replaced by

- UT PE (conventional or phased array) technique alone
- UT TOFD (conventional or phased array) technique alone (geometry and thicknesses of the components, zone coverage, detection of volumetric defects)



Demonstrate that, with the new examination techniques, the guaranteed quality of the parts is still acceptable by an Equivalence Dossier

The qualification shall be carried out on several test blocks containing artificial and realistic flaws (cracks, lack of fusion, lack of penetration, aligned inclusions clustered gas cavities).

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Acceptance criteria ←→ Inspection situation.

- Equipment is manufactured in accordance with workmanship codes.
- Acceptance criteria are related to manufacturing.
- Once the component has been put into operation, inspections aim to assess its fitness for purpose.
- Inspection methods are qualified in regard of detection and characterisation performances

For in service inspection, this is a revolution because the requirements of the Plant Owner have to define the objectives of the inspection with the different parameters of the defect, zone to be inspected and the environment and not a NDT System to implement

At the end, we will have to get acceptance criteria based on fitness for service and not on workmanship standards.

Conclusions

Reducing the risks linked to gamma radiography in NDT has several aspects:

- The adequacy of the use of radiography to an inspection situation must be justified.
- Protection against radiation is a social and human problem which can be solved by a generalisation of best practices:
  - Definition of responsibilities
  - Use of optimised equipment
  - Optimised risk assessment
- Reduction of the number of exposures is related to an optimisation of in-service inspections.

Assessing the replacement of a NDT technique or method for welds by another can involve several specialities:

- NDT expertise
- Weld engineering
- Mechanical engineering

Conclusions (cont.)

Barriers to surpass *:

- All defect detection processes must be reliable, requiring NDT methods to be validated and performed by trained inspectors to recognised standards.
- Validation, training and standards development activities are expensive and can slow the time to market for new NDT technology.
- The high cost of validation, illustrated by the recent examples of a technique that took many years to develop and to be qualified (onwards 5 years), is often due to the need for large numbers of realistic defects in relevant samples and environments
- For business models that do not include through life ownership, NDT is often seen as a burden
- NDT technologies can become buried in companies who have done the validation for a specific task, but do not publish the work: anyone else wishing to use the method would have to pay again

* *Knowledge Transfer Networks "A landscape for the future of NDT in the UK Economy"*

Conclusions (cont.)

Uncertainties remain

- The work done has to be perpetuated
  - Sustainability depends on each one involved in the process
  - Change the habits of the Utilities - Customers
  - Define an objective of inspection and not an NDT System to implement
- The regulatory framework has to encompass actual inspection situations
  - Gaps in codes and standards should be filled-in to include UT
- Economic motivations have sometimes more weight than the risk attached to ionising rays. Would a more stringent regulation foster the development of alternative solutions?

THANK YOU FOR YOUR ATTENTION