Requirements – Qualification Contributions to Safety

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Abstract. Since 25 years, In Service Inspection (ISI) for PWR nuclear power plants has steadily progressed worldwide. This evolution presented different steps: international programs, new regulations and codes issues. The Qualification concept takes form. In some countries, independent inspection bodies have been yet created or are under creation.
In France a Qualification Commission has been settled to respect the Ministerial order of 10 November 1999. This Commission is accredited following ISO 17020 rules. The aim of this Commission is to pronounce qualifications of the NDT methods that fulfill the ISI requirements.
After a short description of these evolutions, the objective of this presentation is to point out progresses in safety through several technical examples of qualified NDT methods:

- a more precise definition of the ISI requirements: searched flaw description, zone to be inspected,
- a stronger control of operating conditions,
- an increased knowledge of ISI performances and limits of qualification resulting of influent parameters technical justifications,
- a technical judgment on the qualification established by NDT experts internal and external to the Company.

It is important to underline first the enormous industrial effort undertaken by the Plant Operator EDF and its subcontractors to perform the qualification trials and obtain related dossiers.
Sensitive to degradation areas and non-sensitive ones are both concerned by this qualification process. This allows a better degradation evaluation and an enhancement of the defence in depth on the plants. By that way the safety level is increasing for an extended plant life.

The qualification – its origins – its goals

The In-service inspection constitutes an essential line of defence in depth for the safety of the nuclear power plants. That participates making sure that the safety level resulting from the design and the fabrication is maintained during operation.
The Non Destructive Testing methods (NDT), used for the In-service inspection, have recorded, in many countries, for 25 years, of significant progress in the direction of a better safety and a greater industrial effectiveness.

In the Eighties, the great international programs such as the DDT [1], the PISC [2] and the ENIQ [3] largely contributed to it.
In the Nineties, the codes and standards [4] and [5] as well as the associated regulation [6] were updated.

Being the French regulation, a new ministerial order was issued on November 10, 1999 for the nuclear power plants.
All the NDT applications must be qualified before their implementation on the main primary and secondary circuits of the PWR reactors.

The qualifications must be pronounced by a commission independent of the development of the NDT application responsible. Since 2002, this commission of EDF is accredited according to the ISO EN.17020 standard and is recognized by the Safety Authority [7].

More in details, the qualification process includes three principal actors (figure 1):

- the Plant Operator defines the requirements of qualification,
- the Design Entity is responsible for the NDT application development which is in general ensured by subcontractors,
- the Qualification Commission puts forth a technical advice on conformity between the performances reached by the NDT application and the requirements defined by the Plant Operator.

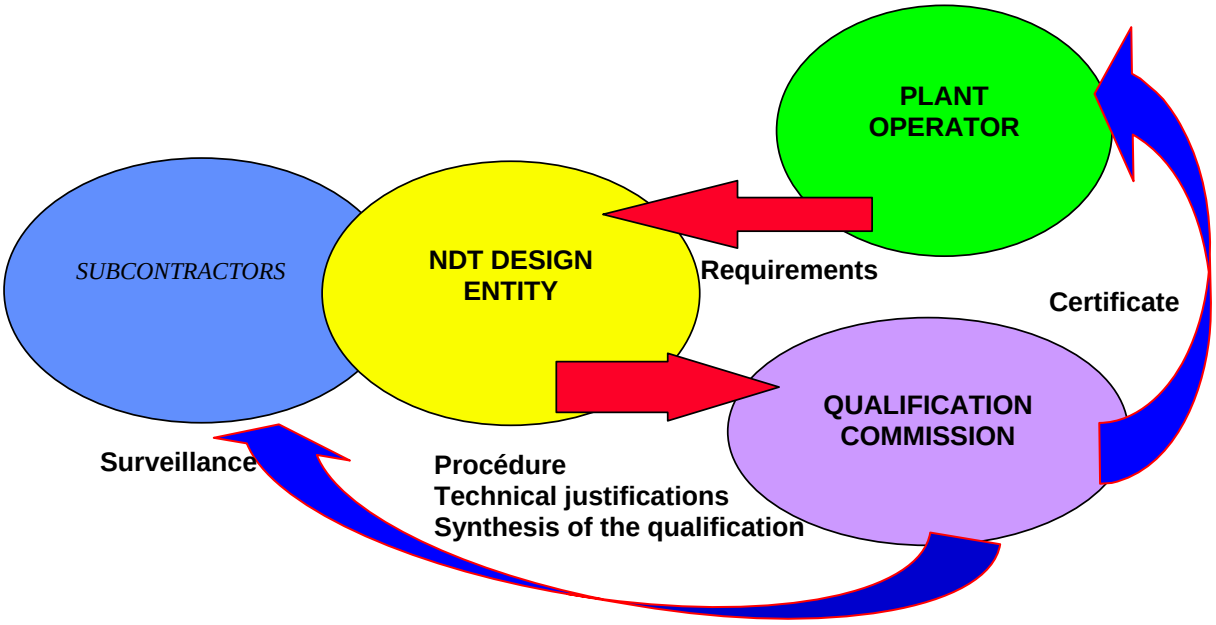

Figure 1: the actors and their parts

The pronounced qualifications file

The Ministerial order identifies three types of qualifications: specific, general and conventional.
The specific and general qualifications deal, on the basis of performance demonstration, with observed flaws, respectively supposed.
The conventional qualifications deal, on the basis of performances explicitation, with these non-sensitive zones to degradation mechanisms, to check the absence of defect there.

The file of the qualifications pronounced by this Commission is presented by technique of NDT and type of qualification (table 1).

	Qualification type		
Technical	Specific	General	Conventional
Ultrasounds	8	7	11
Eddy current	14	2	1
Radiography	-	10	9
Others	1	-	8

Table 1: number of qualifications files (up to 31/03/2006)

Around 70 NDT applications on the primary and secondary circuits have been qualified.

The lessons drawn from the qualifications

The considerable effort made by EDF and its subcontractors resulted mainly in precizing the contents of the qualification and in making technical progresses for the NDT applications.

1. The contents of the qualification

The experience gained by the actors of the process of qualification highlighted two determining axes: the qualification requirements as well as the technical justifications of the performances demonstration.

1.1 The qualification requirements

The Plant Operator defines them according to the importance for the safety and to the elements of feedback experience. It specifies thus, for each zone to be inspected, in particular:

- type of qualification according to the existence of observed or supposed flaws, or within the framework of defence in depth,
- extent of the inspected zone,
- flaw characteristics, in particular the size of the flaw to be detected or to be characterized with the associated accuracies,
- sensitivity of detection, for a conventional type qualification.

Thus it is significant to underline that these initial requirements of qualification, defined by the Plant Operator, are strongly dimensioning for safety, cost but also technical difficulties.

1.2 The performances technical justifications

The objectives of the performances technical justifications consist mainly in:

- identifying the parameters influencing the performances : parameters relating to the searched flaws, the component examined and the procedure used,
- specifying between which limits of these parameters the performances are guaranteed,

- justifying the qualification mock-ups (geometry, material, flaw included), with respect to the performances to guarantee on the component installed on site,
- justifying the criteria of the operating procedure applied for the qualification trials and retained thereafter during on site examination.

The technical justifications for the performances demonstration are in general based on one or several of the following methods:

- physical reasoning (impact of an influent parameter, ...),
- modelling,
- qualification mock-ups trials.

At first, the Qualification Commission gives a professional advice on the representativeness of the mock-ups, the flaws and the qualification trials in regards to the NDT method used.
More generally, the technical justifications make it possible to pass from a conceptual situation (physical reasoning or modelling) or from an experimental situation (laboratory trials) to a more complex real situation of on site inspection (component, flaw, equipment, operating procedure, qualification level of the NDT operator).

Consequently, the technical justifications lead to a more precise knowledge of the performances and associated limits of qualification. It contributes thus to a better appreciation of the safety level of the on site inspected zones by a qualified process.

2. The technical evolutions of NDT applications

The Qualification Commission technical advice about the NDT application conformity mainly leads:

- the Plant Operator to specify the requirements of qualification: the inspected zone extent, the required flaw characteristics, the required sensitivity, …,
- the NDT Design Entity to specify the operating conditions of the procedure allowing to reach performances within the limits of qualification.

Thus, the qualification process has induced progresses for some existing applications. The technical contributions generated by these progresses differ according to the type of qualification: conventional, specific or general.

2.1. The evolutions induced for the conventional applications

Being the qualification requirements , let us take the example of the ultrasonic examination of the containment penetration welds for the Main Steam System.
At the interface between piping and containment, the access is very difficult. The description of the component and its recognition by developed robotics are necessary conditions to ensure a correct extent of the inspected zone (figure 2).

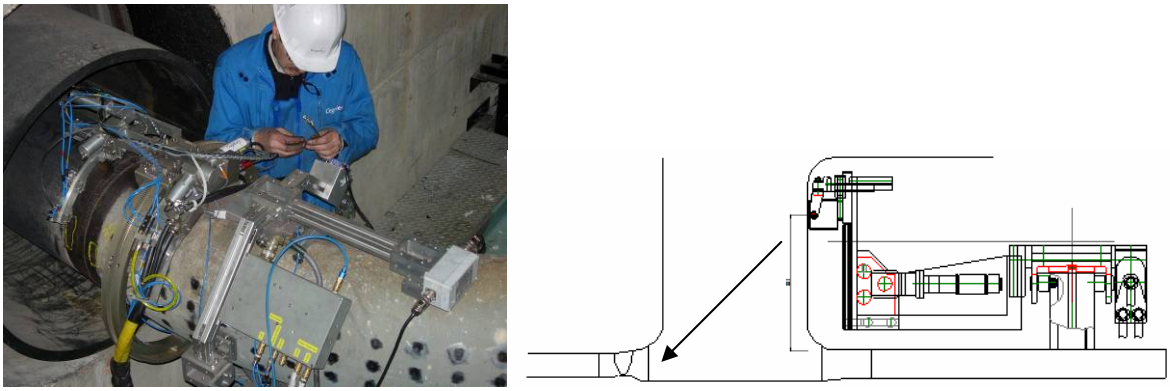

Figure 2: examination of the containment penetration welds

Being the operating conditions of the inspection procedure, another example concerns the ultrasonic examination of the circular pressure vessel welds (figure 3). The technical justifications have precised the accuracy of localization really reached by the process, by taking into account the various influent parameters (cladding thickness, temperature of the coupling water ...).

2.2. *The evolutions induced for the specific or general applications*

Concerning the qualification requirements, in complement with the definition of the inspected zone, it was necessary to more specify the searched flaw characteristics (size and shape).

- With respect to the ultrasonic methods, the planer flaw detection performances depend of the flaw profile. If it remains relatively stable on a beam width, it is possible to obtain a sufficient diffraction amplitude. The point was clarified within the application "pressure vessel core region ultrasonic examination" where cracks under cladding are searched [8] (figure 3).
- With respect to the radiographic methods, the detection performances can be reached, for a plane flaw height given, if the flaw presents a sufficient opening. This point has been specified for the application “bimetallic weld examination between steam generator and primary pipes”, where the searched flaw is a decohesion along the bimetallic junction.

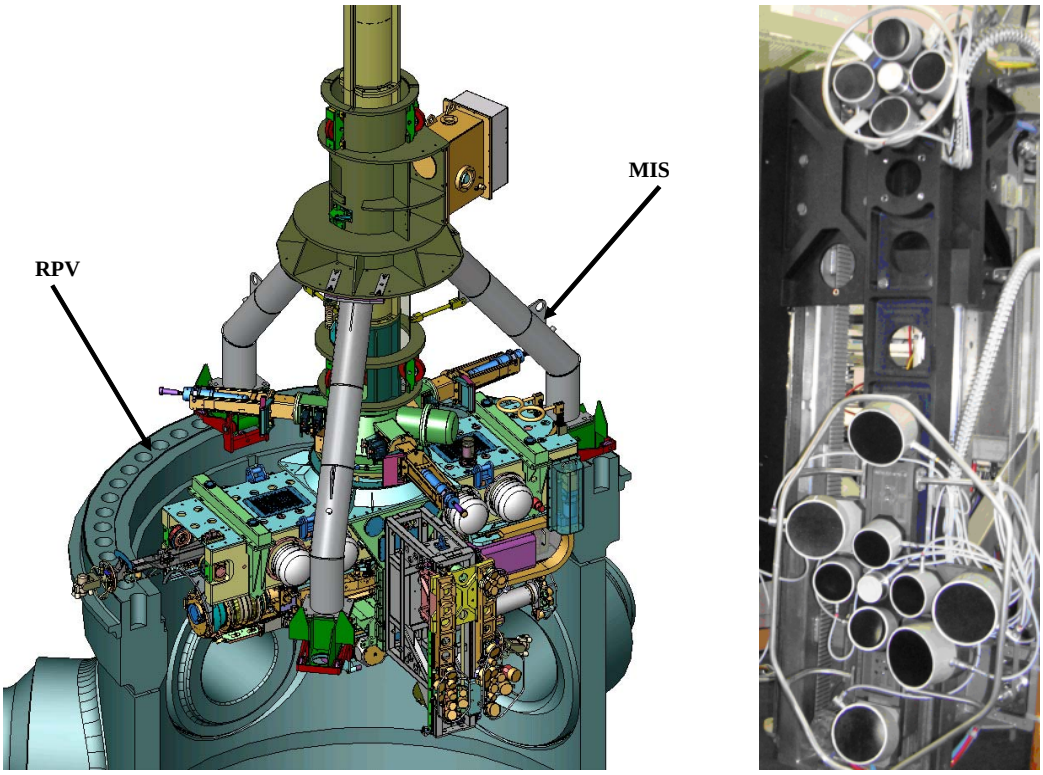

Figure 3: examination of the pressure vessel (manipulator and multi-tool)

Concerning the operation conditions of the inspection procedure, on the NDT application mentioned above, a device (named GAMMATRACK2: figure 4) allowing to check the source position is now used to guarantee the performances within the limits of the influent parameters.

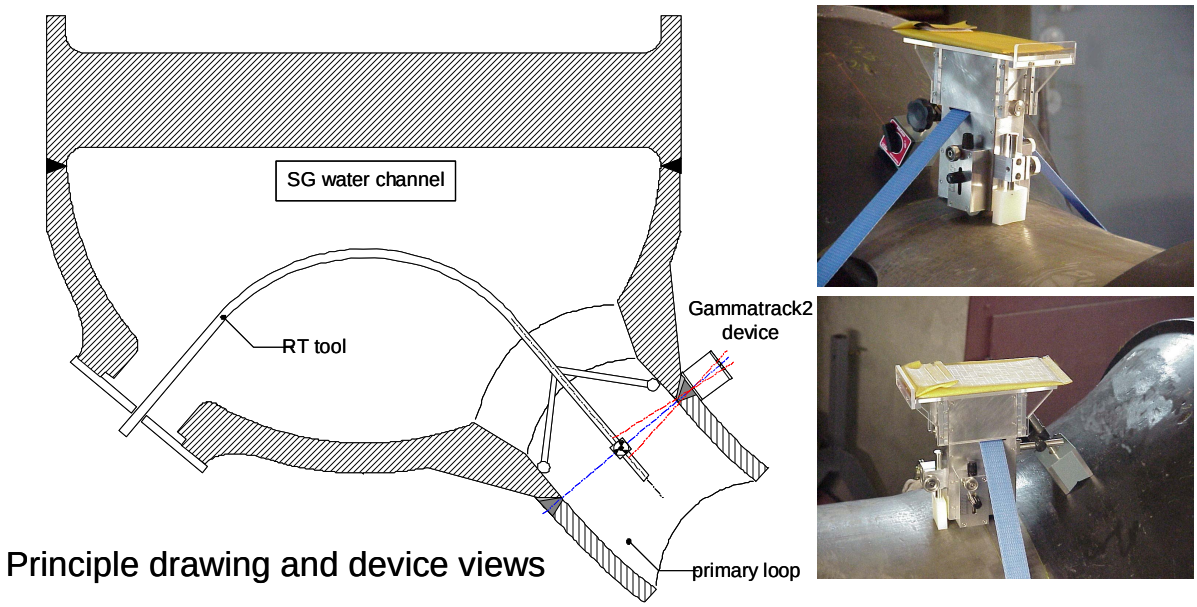

Figure 4: examination of the bimetallic weld between steam generator
and primary pipes (GAMMATRACK2 device)

Another example concerns the application “garmagraphic examination of the weld between the pipe and the elbow of the surge line” (figure 5) where the searched flaw is a fatigue crack at the internal skin. To ensure the flaw detection, it was necessary to redefine the relative positioning between the garmagraphic source and the component.

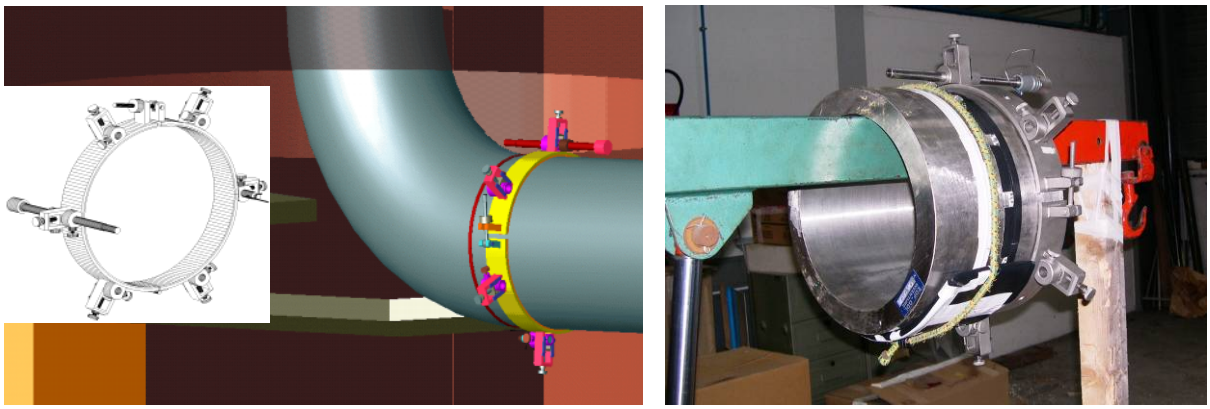

Figure 5: examination of the weld between pipe and elbow of the surge line

For the same application, it was also necessary to specify the limits of parasite noise acceptable between to guarantee the performances.

Thus the radiographic applications adapted to search particular planar defects (fatigue or stress corrosion cracks) cannot be any more basic examinations in simple application of the codes, but require particular and rigorous operating conditions.

Conclusions

The new requirements on NDT qualification established at European level (ENIQ) and at French regulation level (ministerial order - 1999) leads EDF to qualify the NDT applications on the main primary and secondary circuits of PWR.
The industrial effort made by the NDT designers from EDF or its subcontractors is considerable; it resulted in:

- the realization of qualification trials,
- the implementation of qualification dossiers submitted to the Qualification Commission.

About 70 NDT applications are now qualified in accordance with the French regulation.

The conformity examinations of these qualifications by external and internal experts to EDF Company thus contributed to:

- a more precise definition of the qualification requirements in terms of zone to be inspected and of searched flaws characteristics,
- a stronger control of the operating conditions of the examination procedure (sensors acceptance criteria, positioning accuracy of radiographic sources, ...),

- an increased knowledge of the performances reached and limits where the performances are guaranteed, thanks to the technical justifications of the performances demonstration.

Thus the qualification process contributes to reinforce confidence in the results of the in-service inspections and consequently in the knowledge of the state of the installations. The safety level is thus increasing for an extended plant life.

References

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