Looking into other Industries – Qualification of NDT for Swiss Nuclear Utilities

Klaus DRESSLER, Daniel ALGERNON, Philip KICHERER
SVTI Swiss Association for Technical Inspections, Wallisellen, Switzerland

Abstract. Nondestructive inspections have nowadays become a valuable tool for the assurance of safety, quality and durability in the aerospace industry as well as in the nuclear energy sector. In these industries it is essential to know the capabilities and limitations of NDT systems to apply them efficiently. This contribution gives an overview on the qualification methodology used for inspection of safety related components of nuclear power plants (NPP's).

NPP's worldwide are periodically inspected with NDT systems. Before carrying out inspections on site such systems have to demonstrate their inspection capabilities in a qualification process, which is organized, assessed and certified by independent qualification bodies. The Swiss qualification body "QSt" is part of the SVTI.

Generally, an inspection system consists of three elements: personnel, technical equipment and a written procedure. All three parts have to demonstrate their capabilities in achieving a given inspection goal, which depends mostly on the damage tolerance of the component.

The most essential part of a qualification process is the demonstration of the inspection system on realistic test blocks, which simulate the geometrical and material characteristics of the component to be inspected. Test pieces have to contain a statistically sufficient number of test flaws with an appropriate size distribution and positioning. Usually test flaws are manufactured artificially. Their morphology and signal responses should be as realistic as possible. The specific characteristics of different components lead to different test pieces, which simulate the actual components and possible flaws.

Although there are many different component geometries and materials as well as many different types of NDT systems in use, the qualification method itself remains the same.

Furthermore, a benefit of the qualification process is that it helps in thoroughly assessing and therefore improving the performance of NDT systems in general.
The essential elements of NDT system qualifications in Switzerland and examples of automated and fully mechanized UT and ET systems are presented.

1 Introduction

Besides the aerospace industry, the nuclear energy sector is another main field for the application of nondestructive testing (NDT) technology. The inspection techniques applied range from visual inspections over surface inspections such as eddy current, liquid penetrant or magnetic particle testing up to volumetric techniques, which is mostly ultrasonics but also radiography.

Just as in the aviation sector, important decisions regarding the structural integrity and safety of a component are made based on the outcome of the inspections. Thorough assessment of the performance of the inspection systems is essential. For NDT systems applied in Swiss nuclear power plants a qualification system has therefore been implemented on the basis of the European methodology for qualification of nondestructive tests (ENIQ). ENIQ is an association of the nuclear industry in Europe. The methodology as well as the experiences made so far are described herein.

Figure 1: Refuel floor of a reactor**.**

2 Regulations in the Nuclear Energy Sector in Switzerland

Even in comparison to the aviation industry the nuclear industry appears to be more regulated by the government.

In 2008 the Swiss nuclear regulator ENSI released the new guideline ENSI B07 covering the NDE qualification process. According to that the qualification process now had to fulfill the requirements of the European methodology for qualification of nondestructive testing (ENIQ). In consequence, the qualification body needs to be an inspection body of the type A according to EN/ISO 17020. That function was assigned to the Swiss Association for Technical Inspections (SVTI) and manifested in a general contract between the nuclear utilities and SVTI. SVTI is a private organization acting as technical experts and independent inspection body.

Since 2009 all in-service inspection systems used at Swiss nuclear facilities have been qualified according to guideline ENSI B07.

3 Organization of the Swiss Qualification System

The Swiss qualification system is represented by mostly three institutions: the qualification body “QSt”, the steering committee “LAQ” and the advisory board “FBQ”.

3.1 Swiss qualification body “QSt”

QSt as the authority organizes the qualification projects, evaluates practical demonstrations and technical justification documents and issues certificates for the inspection systems (procedures and personnel) after they passed the qualification.

3.2 Steering Committee "LAQ"

The LAQ has the responsibility for the strategic development. It consists of representatives from the Swiss utilities as well as from SVTI.

3.3 Advisory Board "FBQ"

The advisory board is a consulting group of technical experts. Among others the members of the committee are delegates of the Swiss nuclear plants and SVTI.

4 The Swiss implementation of the ENIQ methodology

4.1 Assessment of the testing problem

An important characteristic of the ENIQ methodology is that the qualification process is driven by the specific testing problem and an actual or postulated flaw type. The relevant degradation mechanisms and resulting flaw types need to be determined. Therefore, the experiences made under similar conditions need to be taken into consideration. For determining the relevant size of a defect that the inspection system needs to find reliably (qualification target), a fracture mechanic study is necessary. The potential growth of a flaw of the specific type needs to be taken into account and an adequate safety factor has to be applied.

4.2 Assessment and simulation of the general conditions for the inspection

To make the practical demonstration as meaningful as possible, the relevant conditions, under which the inspection has to be conducted in the field, need to be assessed and simulated for the practical demonstration. For example, this can be limited accessibility of the component, under water conditions (reactor pressure vessel), high temperature, time limitations, orientation of the test object or obstructions in the inspection area.

Within the practical demonstration it is essential that the complete equipment including scanners, cables, probes, etc.is demonstrated under realistic conditions.

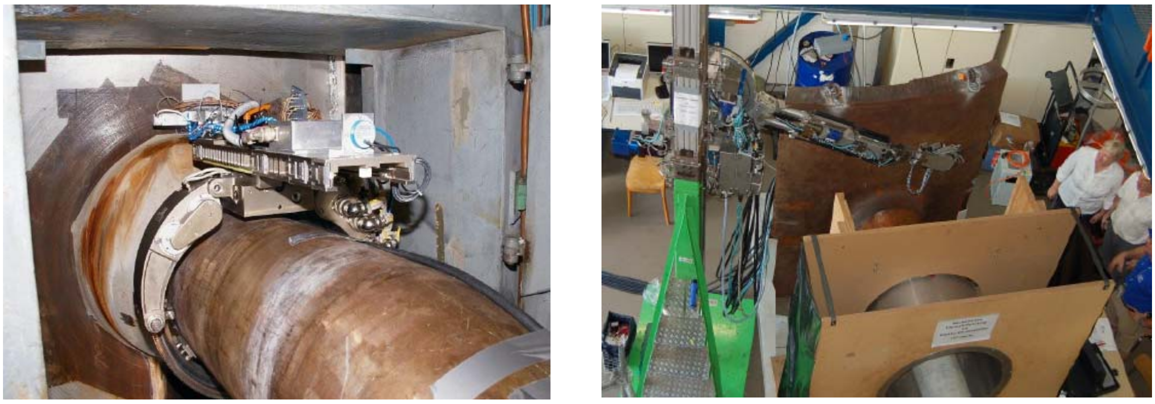

Figure 2: Nozzle inspection on a reactor pressure vessel.
Left: on-site
Right: Qualification process

4.3 Test blocks and test flaws

Test blocks build the basis for any performance demonstration. They need to simulate the testing problem as realistically as possible from the inspection point of view. The test flaws in the blocks can be actual flaws that were found and removed from the field and then implanted in the respective block (field removed flaws) or flaws that are manufactured artificially. The fabrication of artificial flaws simulating a specific degradation process requires a thorough study of actual flaws to be able to make the test flaws as realistic as possible. In many cases it will be neither possible nor necessary to use the same mechanism that causes the flaw in the field. In particular, this can be the case when the actual flaw is caused by long-term degradation processes over many years, whereas the test flaw needs to be fabricated within very short time in most cases.

For a realistic performance demonstration the flaws must have a realistic effect on the measurement principle applied. That requires a thorough study of the flaw type and degradation mechanism on the one hand as well as an in-depth understanding of the testing method and signal characteristics.

In any case great care needs to be taken to ensure that the fabrication of the test flaws will not affect the surrounding material.

Another important aspect is the geometry of the test object. The test block has to reflect the geometry as long as it is relevant for the test method. This can be the thickness of the test object, edges or other geometric characteristics. Nevertheless, for example it can be acceptable to use a flat block to simulate a curved test object if the curvature is small enough and therefore does not affect the functionality of the method. However, although the curvature might not affect the functionality of the actual testing method, it might still affect the applicability of a scanner that is used to move the probe along the test object. This can result in use of a mockup for the practical demonstration of the scanner in addition to the test blocks for the demonstration of the actual measurement method.

Prior to use of the test blocks in a performance demonstration, the test flaws need to be verified thoroughly by all available state-of-the-art means. Any uncertainty in the actual realization of the cracks will result in an uncertainty in the evaluation of the performance demonstration and will therefore limit the value of the qualification in general.

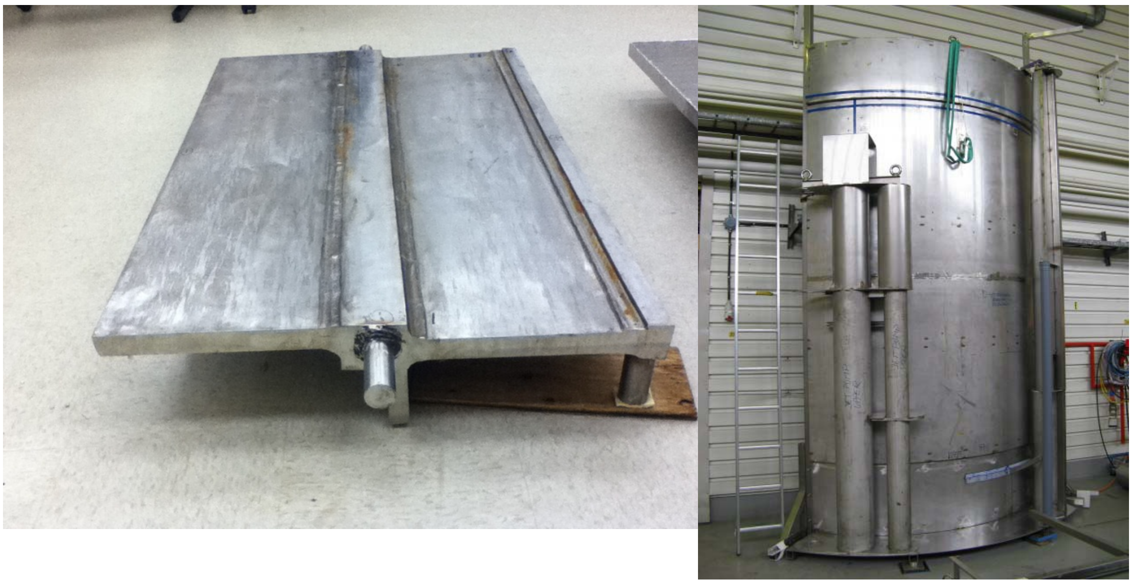

Figure 3: Qualification of core shroud inspection.
Left: Specific test block of a weld.
Right: Full scale mockup of the shroud.

5 Procedure and Personnel

The quality of an inspection depends on both, the procedure itself as well as the personnel that apply it. Therefore, the procedure needs to be described in a way that is understandable for the personnel, provides a thorough and detailed description of the procedure including all essential and non-essential inspection parameters.

A qualified procedure is needed prior to any qualification of personnel. Furthermore, a general certification according to EN 473 for the respective test method is required for any personnel to be qualified for a specific procedure.

6 Practical Demonstrations

Practical demonstrations are the essential element of any qualification and serve to ensure the reliability of the inspection.

In the ENIQ methodology it is distinguished between two different kinds of performance demonstration:

- Tests on “open” blocks with open information about the flaw parameters
- Tests on “blind” blocks where the flaw parameters are kept secret

6.1 “Open” tests

In an “open” test all test block and flaw information is provided to the candidates and other participants involved in the qualification project. The fact that the candidates have that information makes it necessary for QSt to investigate very carefully that the analysis is performed exactly according to the procedure and that the indications reported by the candidate can indeed be realistically obtained from the data. Open tests are usually used only to demonstrate the performance of procedures and the technical equipment, but not for performance demonstrations of the personnel.

6.2 “Blind” tests

All information on the test flaws, such as position, orientation, size and amount, is secure and accessible for the qualification body only. The candidates have to take the test in a controlled area, where it is ensured that they cannot receive any help from other individuals and that no information on the test blocks can be exchanged. They document their findings in an indication list, which is evaluated by the QSt. Blind tests provide a very objective and clear assessment of the performance. Usually, blind tests are followed up by interviews, in which QSt verifies that the candidates did the analysis indeed according to the respective procedure. At the same time it has to be ensured that no information on the test flaws is revealed in the interviews, which would make the test blocks unusable for future blind tests.

7 Acceptance of existing foreign qualifications

Some inspection systems have already been qualified in another country according to the standards there. To avoid unnecessary redundancy in the performance demonstration and to make the qualification as efficient as possible, in Switzerland the foreign performance demonstration can be accepted in parts or completely. Therefore it needs to be identified in how far it fulfills the requirements of the Swiss regulations to define, if necessary, a reduced practical demonstration program.

8 Modeling

To assess the capabilities of a procedure, practical demonstrations on actual test blocks are essential. However, computer simulations can be a very valuable tool in supporting practical demonstrations by providing a theoretical basis for the functionality and investigating the effect of flaw size, position and shape along with variation of the inspection parameters. The relevant parameters can be evaluated by far more than it would ever be possible with real test blocks. However, test blocks are needed for validation of the model.

9 Feedback System

After completion of the qualification project the QSt experts administer the first application of the procedure in the field to obtain some direct feedback on the effectiveness of the qualification. If significant deficiencies become apparent, further qualification effort can be necessary and can be required by QSt.

10 Conclusion

Quantitative assessment of the capabilities of NDE inspection systems is an important aspect for successful and reliable application of NDE in any field. This applies especially to those industrial sectors where such inspections are highly safety relevant, as it is the case in the aerospace industry or the nuclear energy sector.

Since 2008 a qualification system for NDE based on ENIQ methodology has been implemented in Switzerland and is mandatory for inspection systems (procedure, equipment and personnel) to be used at nuclear power plants. SVTI as a type A organization according to ISO 17020 serves as the qualification body (QSt) in that system.

Case specific performance demonstrations are an important element of the ENIQ methodology. Those require the fabrication and use of adequate test blocks. Blind tests as well as open tests are used and require slightly different approaches by QSt.

11 References

[1] The European methodology for qualification of non-destructive testing, Third Issue, EUR 22906 EN, published by the European Commission, Brussels-Luxembourg, (2007).

[2] Guideline ENSI B07 Sicherheitstechnisch klassierte Behälter und Rohrleitungen: Qualifizierung der zerstörungsfreien Prüfungen. Guideline, Eidgenössische Nuklearsicherheitsinspektorat, effective since Sept. 30, 2008.

[3] Dressler, K., Ernst, H., Scherrer, M. and Trautmann, H.: Qualifizierung von Prüfsystemen für wiederkehren-de Prüfungen in Schweizer Kernkraftwerken. Tagungsband der DGZfP-Jahrestagung 2009, http://www.ndt.net/article/dgzfp2009/Inhalt/mi1b3.pdf, (2009).

[4] Dressler, D. and Trautmann, H.: ENIQ based Qualification of NDE Systems in Small Countries – Example Switzerland. Proceedings of the 8th International Conference on NDE in Relation to the Structural Integrity of Nuclear and Pressurized Components, (2010). ^

[5] Dressler, D. and Trautmann, H.: ENIQ based Qualification of NDE Systems in Small Countries – Example Switzerland. Proceedings of the 8th International Conference on NDE in Relation to the Structural Integrity of Nuclear and Pressurized Components Berlin, (2010).

[6] Dressler, K., Ernst, H., Scherrer, M. and Trautmann, H: International Acceptance of NDE Qualification Results and Cooperation of National Qualification Bodies. Proceedings of the 9th International Conference on NDE in Relation to the Structural Integrity of Nuclear and Pressurized Components, Seattle, (2012).