NUGENIA
NUclear GENeration II & III Association

ENIQ METHODOLOGY DOCUMENT

European Methodology for Qualification of Non-Destructive Testing

Issue 4

ENIQ Report No. 61

Technical Area 8
European Network for Inspection & Qualification

March 2019

ENIQ
European Network for Inspection and Qualification

NUGENIA Association

c/o EDF, Avenue des Arts 53, 1000 Bruxelles, BELGIUM

Email: secretariat@nugenia.org

Website: http://www.nugenia.org

This ENIQ Methodology Document was prepared by the NUGENIA Association.

Brussels: The NUGENIA Association

ISBN 978-2-919313-23-5

FOREWORD – BRIEF REVISION HISTORY OF THE EUROPEAN METHODOLOGY FOR QUALIFICATION OF NON-DESTRUCTIVE TESTING

The first issue of the European Methodology for Qualification of Non-Destructive Testing was initiated by Action Group 8 on support for codes and standards of the Programme for the Inspection of Steel Components (PISC III) and finalised by ENIQ. It was published as ENIQ Report no. 1 in 1995. Since then the European Methodology for Qualification of Non-Destructive Testing has been revised three times. The second and third issue were published in 1997 and 2007 respectively. This issue is the fourth issue.

EXECUTIVE SUMMARY

This ENIQ methodology document is the fourth issue of the European Methodology for Qualification of Non-Destructive Testing. It provides guidelines for the qualification of non-destructive testing. Qualification as defined in this document is a combination of technical justification, which involves assembling all supporting evidence for inspection capability (results of capability evaluation exercises, feedback from site experience, applicable and validated theoretical models, physical reasoning), and test piece trials using deliberately defective test pieces.

TABLE OF CONTENT

1. Scope

This document sets out the principles for carrying out qualification of Non-Destructive Testing (NDT) that should be followed in providing confidence that a given NDT system is fit for its purpose.

This document is structured as follows. The foreword briefly describes the revision history of the European Methodology for Qualification of Non-Destructive Testing. This section describes the scope of the document. Section 2 refers to the list of definitions, given in the ENIQ Glossary of Terms [1], which are applicable to this document. Section 3 contains the general principles of inspection qualification, as proposed by ENIQ. Section 4 contains information on how inspection qualification should be implemented in practice. In section 5 the issue of qualification certificates is discussed. In section 6 the responsibilities of the parties involved in the qualification of in-service inspection (ISI) of nuclear power plant (NPP) components are given. Section 7 treats several important issues, such as the hierarchy of the ENIQ qualification documents, the input information to be provided prior to the start of inspection qualification, when to do inspection qualification and some general ideas on how to deal with human factors.

This document was developed specifically for ISI of NPP components. However, it is emphasised that these principles for inspection qualification are equally applicable to manufacturing inspections and to the inspection of non-nuclear components.

The scope of this document is limited to giving general guidelines on how inspection qualification should be carried out. The decision on whether an inspection should or should not be qualified is a matter for agreement between the parties involved. It is expected that qualification will not be required for all routine NDT inspections. Qualification should be considered where the safety or economic consequences of possibly poor NDT performance, and/or the difficulty of applying the NDT, are such that additional assurance is desirable that the NDT can meet the requirements. Qualification may also be considered when a novel NDT technique is proposed.

The document deals with methods for assessing NDT systems to determine whether they are capable of attaining their objectives. It applies to all aspects of inspections which influence their effectiveness. That is the procedure, the equipment and the personnel. In providing an option for personnel qualification, the document does not intend to supplant existing personnel certification schemes but only to supplement them where the NDT imposes requirements beyond those covered by existing schemes, the so-called ‘job specific’ addition to a basic qualification. The precise scope of this qualification is a matter to be agreed between the parties involved.

The document is relevant to any NDT method and so is written in general terms, setting out the principles which should apply. It does not, in itself, constitute a specification for NDT qualification for a specific component but is intended to be used as a basis for development of such specifications. Because the area in which qualification is applied most frequently is ultrasonics, where examples are given for purposes of clarification, these are drawn from ultrasonic applications.

Prior to the start of the inspection qualification it is very important that the parties involved agree on the exact contents of the input information. Input information in this context means all information related to the component, the type and size of defects to be considered and the objectives of the inspection qualification. The inspection procedure is, in principle, also part of the information to be provided. The contents of the input information, to be provided before the inspection qualification starts, is a matter to be agreed between the involved parties. This document is only applicable once all the necessary input information has been provided.

This document embodies the lessons emerging from the many qualification programmes carried out to date, from analysis of the information obtained by the Programme for the Inspection of Steel Components (PISC) on a wide range of test pieces inspected by numerous inspection teams throughout the world, and also from modelling studies, human reliability studies and parametric studies.

The methodology is intended to be flexible so that different countries or organisations can use it to develop qualifications which are consistent throughout Europe but which also meet their different national legal, regulatory and technical requirements.

The document is intended to apply to bodies carrying out qualification of non-destructive testing, and deals with methods for assessing independently whether NDT systems are capable of achieving their objectives. It is intended to assist utilities, qualification bodies, regulatory bodies or those procuring or developing NDT services or equipment which require independent confirmation that the approach proposed is fit for purpose. Indeed, it is intended that the document should encourage developments in NDT by providing a framework within which new developments can be qualified against laid-down performance criteria, so giving potential users the confidence to adopt them without being obliged to follow a detailed prescriptive standard.

This document is not intended to be a code or standard, but it is hoped that bodies issuing codes and standards will make use of it in developing codes and standards for qualification.

2. Definitions

The definitions which are applicable to this document can be found in the ENIQ Glossary of Terms [1].

3. Qualification Principles

3.1 General Principles

Qualification of a NDT system may require assessment of any combination of inspection procedure, equipment and personnel.

NDT system qualification can be considered as the sum of the following items:

i) Qualification of equipment / inspection procedure (see Section 3.3.2);

ii) Qualification of personnel (see Section 3.3.3).

Qualification is achieved through:

i) Technical justification (TJ), which involves assembling all evidence on the effectiveness of the inspection, including previous experience of its application, laboratory studies, mathematical modelling, physical reasoning, experience, training of personnel and so on;

ii) Practical trials (blind or open) conducted on simplified or representative test pieces resembling the component to be inspected.

The appropriate mix of the above sources of evidence must be judged separately for each particular case, although the use of TJ is highly recommended in all cases.

3.2 Elements of Inspection Qualification

3.2.1 Technical Justification

i) Practical reasons limit the number of test pieces that can be used for inspection qualification. Therefore, test piece trials can often only provide limited information on the performance of an NDT system. The purpose of the TJ is:

1. Overcome these limitations by citing all the evidence, which supports an assessment of the capability of the NDT system to perform to the required level; it follows that a better defined confidence in the inspection is provided;

2. Complement and generalise any practical trial results by demonstrating that the results obtained on the specific defects in the test pieces would equally well have been obtained for any other of the possible defects;

3. Provide a sound technical basis for designing efficient test piece trials;
4. Provide a technical basis for the selection of the essential parameters of the NDT system and their valid range.

ii) TJ includes a written statement of the evidence which supports the case that an inspection is capable of meeting its requirements. It comprises a mixture of experimental evidence and theoretical assessment as appropriate. A TJ could include:

- Measurements on practice or development test pieces, if relevant;
- Physical reasoning;
- Feedback from field experience;
- Previous qualifications (where available);
- Relevant round robin trials, such as PISC;
- Feasibility studies and industry trials;
- Results from mathematical models (where available and valid);
- Laboratory studies (where relevant);
- Description of the equipment by the manufacturer;
- Experimental development results;
- Experience and training requirements for personnel.

iii) Sometimes theoretical assessment is needed to relate experimental evidence from similar inspections to the actual situation. Theoretical assessment can also provide independent evidence on the adequacy of the proposed inspection.

iv) A more quantitative approach to theoretical assessment involves the use of mathematical models of the inspection where these are available. Care should be taken in using such models to ensure that they have been validated under the conditions of the particular inspection. Models can be particularly valuable in being able to extrapolate and interpolate practical inspection results gained under one set of conditions to others. In doing this, they enable specific practical results to be generalised. They can also allow results gained on test pieces to be extended to the real component thereby permitting the use of simple test pieces. Further guidance on the use of mathematical models can be found in ENIQ Recommended Practice (RP) 6 [2] (see also Appendix 2).

v) All possible parameters of the equipment, the defects and the component which might have an influence on the outcome of the inspection are called influential parameters. In general, of all the possible influential parameters, only a limited number, the essential parameters, will indeed have a significant influence on the inspection outcome. These essential parameters should be identified and the range in which they can vary should be defined. For the defects and the component the essential parameters are defined in the input information to be provided prior to inspection qualification (see section 4.2) and the qualification is only valid within the defined boundaries. For the NDT equipment and procedure it should be verified during qualification that requirements are included (e.g. calibration requirements) which ensure that the essential parameters remain within the defined boundaries in order not to invalidate the qualification. Further guidance on influential and essential parameters can be found in ENIQ RP2 [3] (see also Appendix 2).

vi) If practice test pieces are made available prior to the start of inspection qualification, the results obtained on them can be very useful in justifying some of the chosen inspection parameters, especially (for ultrasonic inspection) in the case of austenitic components (provided that the practice test pieces are similar in all relevant aspects to the ones used during qualification).

vii) An important element of the TJ is the feedback of field experience, mentioned above. This source of information can become the most important one if the population of similar components or plants is large enough. This feedback has, however, to be validated. The information generated should not be biased by experts' impressions. Evaluation, possibly involving destructive examination, is often necessary to validate the information coming from plant inspections.

viii) If the process of assembling the evidence for the TJ reveals any shortcomings in the capability of the inspection, as compared to the desired performance, the limitations of the inspection should be clearly stated both in the text of the TJ and in its conclusions. The limitations against the desired performance should also be included on any qualification certificate produced by the qualification body (QB).

Further general guidance on TJs can be found in ENIQ RP2 on strategy and recommended contents for TJs [3] (see also Appendix 2).

3.2.2 Practical Trials

i) Practical trials may involve test pieces replicating the component being inspected in size and geometry. The defective condition may also be accurately replicated. If metallurgical flaws are involved, the test piece will be designed to contain flaws of the type judged to be possible in appropriate positions and will normally include the 'worst case' defects judged most difficult to detect, locate, characterise and size for the given defect situation. Such test pieces produce realistic results but are expensive and time-consuming to make and can usually only replicate a small fraction of the flaws which might actually occur.

ii) Simpler test pieces, i.e. test pieces of simpler geometry and/or containing less realistic defects, can also be used but the results need to be extrapolated to the real situation using physical reasoning and modelling. When this is possible it offers a quicker and less expensive route to inspection qualification.

iii) The QB should assess the use of the flaws incorporated in the test pieces as producing either realistic or conservative responses relative to the defects specified by the plant operator.

iv) A further important aspect of practical trials relates to whether or not the test piece is inspected in ignorance of information on the defective condition replicated by the test piece, i.e. whether the trial is blind or open. It is recommended that the qualification of personnel is separated from the procedure/equipment qualification. This will aid exact identification of where any weaknesses lie. The procedure/equipment qualification is preferably done using open trials, both for detection and sizing. An important aspect of using open trials for procedure/equipment is that the inspection results obtained have to be explained and justified in full detail to the QB[1]. A blind trial can be a realistic way of assessing the performance, particularly in terms of whether the combined personnel, equipment and procedure or some combination of these can produce satisfactory results in practice.

v) It is to be noted that test pieces containing real flaws or simulated ones may have to be examined destructively if the test piece results have to be evaluated objectively. Full certification of test pieces which do not require destructive examination need to be documented in the qualification dossier. For example, data could be included on target replication or data from trial defects subject to destructive examination, which demonstrates high levels of control of the as manufactured state of defects.

Further guidance on test piece design and test piece trials can be found in ENIQ RP5 [4] (see also Appendix 2).

[1] It can sometimes be beneficial to ask the inspection team to explain their results to the QB before the true locations and sizes of the defects in the open trial test pieces are revealed to them.

3.3 Qualification Levels and Approaches

3.3.1 Qualification Level and Approach

In practice, qualification of any NDT system can be performed with varying degrees of complexity and cost, varying from a capability statement (a simple form of TJ) based on existing evidence, through to an extensive qualification consisting of a detailed TJ together with open and blind trials on full-scale test pieces. This process may be formalised by providing for a number of different qualification levels and qualification approaches depending on such factors as the safety significance of the component, the role of the inspection in ensuring its structural integrity, and the difficulty or novelty of applying the proposed NDT technique. Guidance on qualification levels and approaches can be found in ENIQ RP8 [5] (see also Appendix 2).

3.3.2 Qualification of Equipment / Inspection Procedure

Where required the inspection procedure and the equipment can be qualified by TJ, open trials or both.

i) Where an item of the equipment falls within the scope of a national, European or international NDT standard or other written specification, the qualification should include, where appropriate:

- A study to determine the relevance of the standard or specifications to the specific case;
- Proof of compliance with the standard(s).

ii) Where an item of the equipment does not fall within the scope of an appropriate standard or specification or the plant operator does not want to use existing standards or specifications, the qualification should ensure that provision is made to measure the equipment essential parameters, identified during the analysis of the influential parameters. Such provision might be made through including appropriate calibration requirements in the procedure, through commissioning trials of the equipment or through open practical trials. The inspection procedure should identify the essential parameters and should specify allowable values and tolerances.

iii) Qualification of inspection procedures using TJ involves the following:

- Assessment of the NDT systems capability and reliability against the inspection objective;
- Assessment of the technical adequacy of the inspection procedure;
- Assessment of the analysis of the essential parameters;
- Checking that all those inspection procedure essential parameters which affect the outcome of the NDT significantly, and the ranges within which they can vary, are specified and that they are, if necessary, considered in the practical trials;
- Checking that the inspection procedure is written in a sufficiently systematic and unambiguous way that its application is reproducible (see ENIQ RP12 [6] and also Appendix 2).

iv) Open or blind practical trials should be performed for the inspection procedure, where a sufficient demonstration of its adequacy through TJ is not possible.

3.3.3 Qualification of Personnel

Personnel, using qualified inspection procedures and equipment, should be qualified through one or any combination of the following:

- Certification through a national NDT personnel certification scheme;
- Theoretical and/or open practical examination;
- Blind trials.

i) Any personnel certification requirements invoking relevant national NDT personnel certification schemes (EN ISO 9712, for example) should be specified in the inspection procedure. Any additional

personnel training requirements should also be specified there. The QB should satisfy itself that these requirements are appropriate.

ii) If no relevant scheme exists or if extra personnel qualification is needed, the qualification plan should state the additional practical and theoretical examinations needed beyond those in the national certification scheme, include these in the qualification plan and ensure that the inspection procedure also includes the necessary requirements. For automated non-destructive inspections, carried out by a team of inspectors, it may be necessary for only certain designated members of the team to be qualified, for example those carrying out the data analysis and interpretation. The qualification plan should describe the proposed system.

ENIQ RP10 [7] (see also Appendix 2) provides guidance on qualification of personnel.

4. Conduct of Qualification

The most important steps before and during inspection qualification, with references to the corresponding sections of this document, are given in Appendix 1. Note that the steps may be taken in a different order from that given in Appendix 1.

4.1 Contents of the Qualification Dossier

The qualification dossier is a file assembled by the QB. It is recommended that the following information is included as a minimum:

- Input information (see section 4.2);
- TJ (see section 3.2.1);
- Qualification plan (see section 4.3);
- Results of the qualification (see section 4.4).

More detailed advice on the contents of the qualification dossier is given in ENIQ RP4 [8] (see also Appendix 2).

4.2 Input Information

Prior to the start of inspection qualification all necessary input information for the qualification must be made available. These input data are typically:

1. Objectives of the inspection qualification;
2. Full description of the component to be non-destructively inspected;
3. Types, dimensions, orientations, locations and morphologies of defects to be detected and/or sized, depending on the defect situation considered (see the last paragraph of this section below);
4. If applicable, the acceptance and rejection criteria for any detected defects;
5. Inspection performance (detection, sizing, location and characterisation) to be achieved;
6. Required qualification level, for those using this concept (see ENIQ RP8 [5]);
7. Inspection procedure, equipment and personnel requirements.

In general, the information for points 1 to 6 is made available by the plant operator whereas the inspection procedure is prepared by the vendor. More information can be found in section 7.2.

The information on the defects to be detected and/or sized (point 3 above) will generally be determined from applicable codes and standards, or by metallurgy and fracture mechanics experts, preferably in discussion with NDT experts. Only the outcome of these deliberations is relevant to inspection

qualification and is provided as input information under point 3. The detailed metallurgical deliberations and fracture mechanics calculations, including consideration of safety factors etc., are outside the scope of qualification and do not need to be provided.

4.3 Qualification Plan (Conduct of Qualification)

Following agreement between the involved parties on the qualification approach required, a qualification plan should be submitted to the plant operator for acceptance. In the qualification plan the way the qualification will be implemented in practice is described. The qualification plan should contain, at least, the following information:

- Objectives of the inspection qualification;
- Qualification level if this has been specified;
- Way the TJ and inspection procedure will be assessed;
- Details of how the practical trials will be conducted (blind and open);
- Details of the qualification test pieces (in the case of blind trials some aspects will be confidential);
- Way the results of the qualification will be evaluated.

The qualification plan is produced taking into account all the input information (see section 4.2) and the objectives set out at the beginning.

The following points should be considered when producing and implementing the qualification plan:

a) Before starting any practical trials as part of qualification, it may be appropriate to brief the NDT personnel on the conduct of the trials using the inspection procedure. The availability of test pieces will have been discussed with the plant operator. Where practice test pieces are made available, they should not subsequently be used in blind trials. The practice test pieces can be used to optimise the inspection procedure and the results obtained can be used in the TJ.

b) The only information which can be withheld is that relating to the detail of the defective condition of any test piece where release of information would prejudice the ability to carry out blind trials if these are required. Such retention of information should be agreed between the relevant involved parties.

c) The QB should assess the TJ and the inspection procedure. Where the assessment reveals deficiencies in the inspection procedure, the QB should provide feedback to the plant operator or inspection company on the need for change. Responsibility for provision of an amended inspection procedure is with the plant operator (though in some cases the procedure will actually be written by the inspection vendor – see Section 6 below). The QB should determine the test piece trials which are needed so that, when combined with the TJ, they together provide convincing evidence on the adequacy of the NDT to meet the defined objectives.

   In some cases, the long lead times involved may necessitate the initiation of test piece procurement for the trials before the full TJ is available. The information in the TJ relating to test piece design is often available at an early stage in its preparation, frequently once the physical reasoning part is complete. It is acceptable for test piece design and procurement to begin once this information is available to the satisfaction of the QB, even if the rest of the TJ remains to be completed.

d) The need for practical trials, either blind or open, should be determined and the test pieces identified. The specification for these in terms of geometry, size and the defects contained should be included in the qualification plan. Where blind test piece trials are a major element of the qualification process, a sufficiently large number of defective and blank zones should be considered in order to minimise the influence of chance on the final results. A bank of test assemblies (test pieces and available components) should be assembled to present enough different situations to the inspection procedure and personnel to be qualified.

e) As already discussed in section 3.1, it is recommended that the qualification of the inspection procedure / equipment is separated from the personnel qualification. This will aid exact identification of where any weaknesses lie. Furthermore, qualification of the inspection procedure / equipment should be done through TJ and, if required, open trials, for both detection and sizing. Note that the qualification plan may be different for detection and sizing. An important aspect of qualification of the inspection procedure / equipment through open trials is the fact that the inspection results obtained are explained and justified in full detail to the QB. A blind trial, on the other hand, can be a realistic way of assessing the performance, particularly in terms of whether the combined personnel, equipment and procedure or some combination of these can produce satisfactory results in practice.

f) The QB should present in the qualification plan how the qualification results will be assessed.

g) Test reports and examination papers produced during the qualification process should be archived as part of the qualification dossier.

h) Times and conditions available for qualification tests should be included in the qualification plan where relevant and be commensurate with times and conditions available for the site inspections. However, it is recognised that realistic simulation of site conditions and time constraints will not always be necessary or indeed possible.

When practical assessment is carried out using blind trials, the following steps should be taken in addition to the above:

- All test pieces used for blind trials should be uniquely identified but all identification marks should be concealed during qualification. When not in use for qualification purposes they should be inaccessible except to authorised staff. Likewise manufacturing drawings, details of defective conditions and all documentary information relating to flaws should be secure except to authorised staff.
- All blind trials and written personnel examinations should be invigilated continuously. Steps should be taken by the QB to ensure that the inspection carried out on test pieces is in conformity with the written procedures and that data gathered from blind trials is not removed from the qualification site. Care should be taken to meet this requirement when equipment with electronic memory capability is used.

4.4 Conclusion of the Qualification

The qualification dossier should contain all the data and results generated during the qualification. The evaluation of the results must be done according to rules set out in the qualification plan that refer to the different options and that are part of the qualification plan. The evaluation can vary from a statistical assessment to a judgment by the QB. The reasoning must be included in the qualification dossier. The results may contain information obtained after destructive examination of the test pieces, if executed.

In some cases, the plant operator and regulator may agree that the results of the qualification should be summarised in a single document. This document, a “Summary of Technical Evidence”, contains, or gives references to, all the evidence for the capability of the proposed inspection, both the TJ and the results of any open and blind trials. It thus combines and summarises in a single document all the key information in the qualification dossier. If such a document is produced, the qualification dossier is still compiled, but is not generally issued. The qualification dossier remains accessible if required by, say, the regulatory body.

4.5 Updating of the Qualification Dossier

i) The qualification dossier should be updated with results of other NDT systems, applied to the same components, which have already undergone qualification.

ii) If feedback from site experience shows evidence which deviates from what was obtained during qualification, then the qualification dossier should be updated accordingly. The consequences of the feedback results should be analysed and assessed.

4.6 Post-Qualification Follow-up

Following qualification, the QB may provide advice on meeting the requirements of the actual inspections or on technology transfer in the light of knowledge or experience gained through the qualification process. Where blind trials are involved, no information regarding defective conditions in the test pieces used should be given if the test pieces are to be used for further blind trials. Statistical information, if available, on the success achieved on a number of test pieces and errors of measurement, if appropriate, may be passed on. The degree of post- qualification support to be provided by the QB should be agreed between the parties concerned.

5. Qualification Certificates

5.1 NDT Equipment and Procedures

i) Where required by the plant operator or inspection company as appropriate, in cases where qualification has been successful, the QB should issue a certificate to the plant operator or inspection company, which identifies the inspection procedure and/or equipment which was qualified and the criteria used for assessment.

ii) Qualification certificates for procedures and equipment may be considered as being valid indefinitely unless changes are made to the procedures or equipment or to any mandatory code whose requirements must be met. If, following changes to alter the procedure or the equipment, the plant operator wishes to extend the qualification certificate, the QB should seek technical information from the plant operator to justify extension. Only if then satisfied that the changes have not invalidated the certificate, should the QB extend the certificate to the new circumstances. If not satisfied, the QB should identify the further checks it believes to be necessary and make proposals to the plant operator for these to be carried out as a condition of extending the certificate.

   The process of consulting the QB described in the previous paragraph is not necessarily required in cases of minor non-technical changes which cannot conceivably affect the inspection performance (e.g. purely editorial changes to procedures). Technical changes should always be submitted to the QB.

iii) When changes are needed to meet updated code requirements, the plant operator should request the QB to consider the need for changes. The timescale for changes to be implemented is a matter for the regulatory body or plant operator, depending on circumstances.

iv) In cases where the qualification process has shown that some of the qualification requirements cannot be met, then one of the following options must be followed:

   - Qualification requirements should be revised, by agreement among all the involved parties, so that the requirements can be met.
   - Limitations should be explicitly stated on the qualification certificate.
   - Limitations should be clearly stated both in the text of the TJ and in its conclusions.

An example of such limitations might be if the qualification requirements in the input information have been met for defect detection but not for sizing.

5.2 Personnel

The text in this section refers to personnel qualification carried out as part of the process of qualifying a specific inspection. The personnel qualification certificates referred to are those issued for that specific inspection. They must not be confused with the certificates issued under a general personnel certification scheme such as EN ISO 9712.

i) It is recommended that qualification certificates for personnel are generally made valid for a limited time period. The precise term should be agreed with the plant operator at the outset. If, at the end of this period, the plant operator or vendor can produce documentary evidence of continued

satisfactory involvement by staff in the qualified inspection, the certificate may be renewed for a further period. Multiple renewals by this documentary route may also be allowed, but eventually recertification is required after an agreed time period has elapsed from when the original certificate was awarded.

ii) In cases where the qualification process has shown that some of the qualification requirements cannot be met, any such caveats must be explicitly stated on the qualification certificate. An example might be if the qualification requirements in the input information have been met by a particular individual for defect detection but not for sizing.

iii) Where any applicable code or standard requirements change, the updated requirements should be implemented at the next renewal.

5.3 Regulatory Requirements

When qualification has been conducted because of regulatory requirements the certificates issued by the QB do not constitute approval of the inspection. Such approval must come from the regulatory body using the certificates as supporting evidence.

5.4 Format

The format of any qualification certificate to be issued (including that for the personnel) is a matter to be agreed between the parties involved.

6. Responsibilities of the Parties Involved

In this section the roles and responsibilities of the different parties involved in inspection qualification are described. It should be stressed that the responsibilities, as described in this section, are applicable to the case of in-service inspection of nuclear power components only. For the inspection of non-nuclear components or for manufacturing applications some or all of the responsibilities described in this section are either not necessary or taken over by other parties. For example, if inspection qualification is required for a specific non-nuclear application, because inefficient NDT would have important economic consequences, it may be that no regulatory requirements exist. The plant operator could then, if necessary, take over the responsibilities attributed to the regulatory body in section 6.2. In the case of qualification of a manufacturing inspection the manufacturer will in many cases be responsible for the qualification and will take over many of the responsibilities attributed to the plant operator in Section 6.1.

6.1 Plant Operator

In all European Union countries (and Switzerland and Great Britain) the plant operator (licensee), being responsible for the safety of his installations, must take care of the surveillance of their nuclear power plants. This is normally done, among other means, through in-service inspections assigned to vendors of inspection services. The plant operator is responsible for the adequacy of the inspections and must provide the evidence to the regulatory body. The plant operator provides input for the qualification dossier that should be prepared by the QB. The QB can require additional information to complete the qualification dossier, if they judge this to be necessary. The following actions are thus the responsibility of the plant operator:

- Plant operator decides on the items that require inspection qualification, by considering the component to be inspected and the defects to be detected. The list of such cases is updated taking into account national and international field experience, codes and standards, operating license requirements, etc.
- Plant operator gives to the vendor and to the QB all the required input information (components, defects, objectives of the qualification) pertaining to the inspection(s) to be qualified, including the inspection performance to be met.

- Plant operator has the ultimate responsibility for the inspection procedure and TJ. In some cases these documents will be written by the plant operator, in others by the inspection vendor (see section 6.3 below).
- Plant operator may assess the qualification plan proposed and comment upon it. Depending on the particular relationship between operator and regulatory body, the plant operator could approve the qualification plan in some countries.
- Plant operator is responsible for ensuring that the results of the qualification exercise (including any limitations) are taken into account in, and remain applicable to, the subsequent inspection.
- Plant operator takes the necessary steps to enable the QB to keep the qualification dossier updated with national and international field experience.
- Plant operator supervises the whole of the inspection activities that affect the performance, especially receipt and verification of the equipment, qualification of the personnel, contents of the procedures, logistics of the operations and evaluation of the results.

6.2 Regulatory Body

In all countries the regulatory body has been assigned the task of monitoring and evaluating safety and ensuring that the licensees fulfil the conditions of their site licences. In the context of NDT qualification the regulatory bodies either define or review the basic qualification requirements that must be met from a safety point of view. The regulatory body also undertakes audits, periodic reviews and monitors the licensees' compliance with the qualification requirements.

6.3 Vendor of Inspection Services

By agreement between the vendor and the plant operator, in some cases the vendor himself writes the inspection procedure and the TJ, while in other cases one or both documents are written by the plant operator. The vendor's responsibilities, e.g. training and production of the training dossier, should be specified in the qualification plan as detailed in RP10 on personnel qualification [7]. The vendor performs the inspection. The vendor must provide all the necessary elements allowing the QB to set up the qualification dossier. The vendor, if requested, has to participate in the qualification of the inspection procedure, e.g. when instruments and personnel are included in the qualification. The vendor helps the QB to keep the qualification dossier up to date.

6.4 Qualification Body

The responsibility of the QB in this text relates to the inspection procedure and equipment, and also to the personnel in the cases where operators are involved in the qualification. The QB has the following responsibilities:

- Preparation of the qualification plan;
- Assessment of the inspection procedure and TJ;
- Evaluation of the need for design of test pieces and their fabrication;
- Invigilation (or proctorship), if applicable, of any test piece trials;
- Assessment of the qualification results;
- Assembling and issuing of the final qualification dossier (or associated summary of technical evidence, see Section 4.5);
- Issuing qualification certificates.

The need for the QB to be separate from the plant operator is a matter to be determined by the plant operator and by the regulatory body if qualification is carried out as a result of regulatory requirements. Where it is necessary for the QB to be independent but it is within the plant operator's organisation, the

QB should have a quality system which guarantees its independence from commercial or operational considerations.

Further guidance on the requirements for a QB, and on the different types of QB, are given in ENIQ RP7 [9] (see also Appendix 2).

7. Various Issues

7.1 Hierarchy of Documents

As stated before, this document is intended to provide a general framework for the development of qualifications for the inspection of specific components, to ensure that they are developed in a coherent and consistent way throughout Europe while still allowing qualification to be tailored in detail to meet different national requirements. It should be stressed that in this general document one will not find a detailed description of how the inspection of a specific component should be qualified.

However, more detailed guidance on how to apply the general principles for inspection qualification developed in this document is available in a series of ENIQ RPs referenced throughout this document and listed in Appendix 2. Organisations are free to make use of these RPs at national level, as they see fit. They can be downloaded from the NUGENIA website www.nugenia.org under Resources.

Qualification plans are developed by qualification bodies for individual qualifications, using the RPs for guidance. These qualification plans contain the detailed qualification requirements for a specific inspection, or group of inspections of specific geometries and sizes of components and relate to the precise way in which the NDT method is applied in practice. These qualification plans need to reflect the technical, legal and regulatory requirements in the country of application.

7.2 Input Information

At the outset of qualification, the QB should agree with other relevant involved parties the objectives of the inspection and its qualification. The items discussed below, which are an essential part of the input information, should be available to the QB before qualification commences and comprise the initial part of the qualification dossier. If not immediately available, the QB should agree with the other involved parties on the steps to be taken to ensure that the information necessary is available before qualification commences. Further guidance on the parameters which should be provided in the input information is given in ENIQ RP2 [3] (see also Appendix 2).

i) The component: the item to be non-destructively inspected, and all features of the item which influence the inspection and its qualification. This may include its size, geometry, surface finish, material composition, restrictions to access etc., depending on the NDT method to be used and range of variation of relevant characteristics.

ii) Flaw population: The flaws or conditions which must be detected by the actual NDT system in the real components. The information required will usually include size, position, type, orientation and any other factors affecting response to the inspection method used. In the framework of in-service inspection of nuclear power plant components, it is possible to distinguish three different cases depending on the nature of the defects. Therefore, the following three defect situations are considered: specific, postulated and unspecified.

   a) Specific defect situation

      A specific defect situation relates to the case where specific defects have been found in a specific component. The type of damage is potentially widespread (“repeatable”) and could be found on other similar components. The type of defect to be detected is well known. An example of a specific situation is the presence of sub-clad cracks in the reactor pressure vessel.

   b) Postulated defect situation

      A postulated defect situation relates to the case where the existence of defects of particular types is postulated in a particular component. The exact characteristics of the defects are not

known and have therefore to be postulated using, if applicable and available, experience obtained on similar defects which have occurred in other components of the same general type. An example of a postulated defect situation is the postulated presence of mechanical fatigue defects in reactor pressure vessel components.

c) Unspecified defect situation

An unspecified defect situation relates to those cases where neither a specific defect has been detected, nor a defect has been postulated or a damage process has been identified. Inspection is done in a preventive way for surveillance purposes only or because it is required by an existing prescriptive standard.

In the case of an unspecified defect situation, where the defect types and positions cannot be specified, no inspection qualification is possible.

iii) Inspection objectives (usually included in TJ):

Detection and false calls: The detection rate which the relevant involved parties regard as necessary for the actual inspection. (This may arise from a regulatory requirement.) Qualification will aim to assess whether this detection rate is attainable for the inspection method chosen. Likewise, if false calls are important in the particular application, the performance which is regarded as unacceptable should be established.

Acceptance and rejection: If applicable, the acceptance and rejection criteria for detection should be defined.

Sizing and characterisation: If the objective of the inspection is to detect and size flaws, the parameters which must be measured such as length, through-wall extent, ligament and location should be defined and the maximum acceptable tolerances of reported flaw locations and sizes from actual locations and sizes respectively should be established. Any defect characterisation requirements should also be defined.

Inspection time and conditions: Any limits on the time available for the site inspection or limitations imposed by site conditions.

iv) Qualification level and/or approach required, for those using this concept (see ENIQ RP8 [5]).

v) The inspection procedure, which is in fact the object of the qualification plan, should ideally be known before the qualification starts, but in many cases a procedure will not exist at this stage. As a minimum, sufficient information on the inspection should be available to allow the qualification plan to be finalised, to the satisfaction of all parties. The description of the inspection procedure must consider all aspects such as the techniques, equipment, decision steps used and personnel.

In practice it is often the case that the process of qualification reveals weaknesses in the initial inspection procedure, and the inspection procedure is revised accordingly. This iterative development of the inspection procedure can be accommodated within the overall qualification process, provided that (a) at least an initial version of the inspection procedure is available before qualification starts; (b) the final qualification is conducted against the final version of the inspection procedure.

vi) The required qualification for the personnel and the specification of any additional qualification necessary that would be part of the qualification of the inspection in question.

7.3 Matters to be Agreed

The following are thus all matters to be determined by the plant operator, and if required agreed with the regulator, before inspection qualification starts:

- For any given case, the decision on whether an inspection should or should not be qualified;

- Qualification level and/or approach, for those organisations who are using this concept (see ENIQ RP8 [5]);
- Exact definition and classification of the defect situation;
- Way the defect situation affects the objectives of the qualification plan that will be followed.

Besides the technical decisions, some other aspects must be agreed between the different parties, such as:

- Interaction between the parties (mainly with the regulator);
- Facilities available to the QB;
- Staff capability and certification used for the conduct of the qualification.

7.4 Human Factors and Expert Evaluation of Inspection Results

7.4.1 Human Factors

When qualification is intended as a full validation of an inspection process including working conditions and human factors, the operators must be involved in the qualification process. This could require practical trials involving the whole of the instrumentation and executed in conditions as similar as possible to real conditions. Industrial surroundings, inspection times and access restrictions should be simulated.

Assurance of the effectiveness of the human operators during the actual inspection cannot be obtained through qualification alone. Additional assurance can be obtained through a quality assurance procedure, use of audit, repeat inspection, good management practice, freedom of operators from excessive time pressure, etc.

7.4.2 Expert Evaluation of Inspection Results

In the procedure all the decision steps related to the combination and interpretation of the results of the different techniques allowing one to arrive at the final result should be written down in a clear, logical and traceable manner. This will minimise the extent to which the results depend on the experience of the evaluating expert.

Inspection procedures in which the decision steps are not described in full detail are not suitable for qualification because the performance could depend excessively on the experience of the expert.

REFERENCES

[1] *ENIQ Glossary of Terms – Issue 3*, ENIQ Report no. 62, The NUGENIA Association, 2019.

[2] *ENIQ Recommended Practice 6: The Use of Modelling in Inspection Qualification - Issue 3*, ENIQ Report no. 57, The NUGENIA Association, 2018.

[3] *ENIQ Recommended Practice 2: Strategy and Recommended Contents for Technical Justifications – Issue 3*, ENIQ Report no. 54, The NUGENIA Association, 2018.

[4] *ENIQ Recommended Practice 5: Guidelines for the Design of Test Pieces and Conduct of Test Piece Trials – Issue 3*, ENIQ Report no. 56, The NUGENIA Association, 2018.

[5] *ENIQ Recommended Practice 8: Qualification Levels and Approaches – Issue 2, ENIQ Report no. 59*, The NUGENIA Association, 2018.

[6] *ENIQ Recommended Practice 12: Strategy and Recommended Contents for Inspection Procedures*, ENIQ Report no. 63, The NUGENIA Association, 2019.

[7] *ENIQ Recommended Practice 10: Personnel Qualification - Issue 2*, ENIQ Report no. 60, The NUGENIA Association, 2018.

[8] *ENIQ Recommended Practice 4: Recommended Contents for the Qualification Dossier - Issue 2*, ENIQ Report no. 55, The NUGENIA Association, 2018.

[9] *ENIQ Recommended Practice 7: Recommended General Requirements for a Body Operating Qualification of Non-Destructive Tests – Issue 2*, ENIQ Report no. 58, The NUGENIA Association, 2018.

APPENDICES

Appendix 1: Major Steps to be followed prior and during an Inspection Qualification

Note that this table only includes the major steps and that the steps need not necessarily be performed in the order listed.

Step no.	Task	Relevant section(s) and ENIQ RPs
1	Make available all required input information concerning component, defects, inspection and qualification objectives	4.2, 7.2
2	Optimise inspection procedure using typical reference / training test pieces	3.2.1, 4.3
3	Prepare inspection procedure and TJ	3, 4, RP2 [3]
4	Assess submitted inspection procedure and TJ	3.2.1, 3.3.2, 4.3
5	Propose qualification plan including open and blind test piece trials, as required	3.3.1, 4.3, RPs 5 [4] and 8 [5]
6	Accept / refuse qualification plan	4.3
7	Conduct open trials for inspection procedure / equipment, if required	3.2.2, 3.3.2, 4.3
8	Issue / refuse qualification certificate for procedure / equipment	5.1
9	Conduct complementary qualification of personnel using qualified inspection procedure / equipment	3.2.2, 3.3.3, 4.3, RP10 [7]
10	Issue / refuse qualification certificate for personnel	5.2, RP10 [7]
11	Compile and finalise qualification dossier	4.1, 4.5, RP4 [8]
12	Acceptance of qualified inspection by plant operator (and / or regulator)	6

Appendix 2: List of Recommended Practices

A Recommended Practice (RP) is a document produced by ENIQ to support the production of detailed qualification plans by individual countries or organisations. The hierarchy of documents in qualification is described in Section 7.1 of the main document. This describes the different documents, the responsibility for their production and their scope.

A RP is the next level of document below this methodology document. As such, it is still general in scope, which means that valuable advice can be given by ENIQ to promote a uniform approach to qualification throughout Europe, while leaving the detail of how qualification is to be done to be determined at the national level in line with the regulatory and technical requirements in that country. Organisations are free to make use at national level of the RPs, as they see fit.

The table below gives a list of the currently available RPs relevant to this document, with a brief summary of the scope of each.

RP2	**Strategy and Recommended Contents for Technical Justifications**
	The objective of RP2 is to support licensees, qualification bodies and inspection vendors to produce and assess a TJ. RP2 includes what and how the contents in a TJ could be described, including the definitions of influential and essential parameters and how these have to be treated. The appendices give examples of influential parameters for three commonly used inspection techniques.
RP4	**Recommended Contents for the Qualification Dossier**
	The objective of RP4 is to support licensees, inspection qualification bodies and inspection vendors to produce and assess a qualification dossier. The latter includes all the information relevant for the definition and the execution of an inspection qualification.
RP5	**Guidelines for the Design of Test Pieces and Conduct of Test Piece Trials**
	RP5 identifies issues to be considered when designing test pieces for use in experimental inspection qualification trials and provides recommendations for conducting these trials. This document helps plant owners, qualification bodies and inspection vendors in the execution of their respective roles in the qualification process. It is also intended to help the user in understanding the influence of essential input for the design of test pieces. Practical trials of NDT systems play an important role in the qualification of both inspection procedures and inspection personnel. RP5 addresses consecutively the design of practical trials, test piece design and test piece fabrication.
RP6	**The Use of Modelling in Inspection Qualification**
	The main objective of RP6 is to advice inspection vendors and NDT engineers on how to use modelling to develop inspection techniques and on how to use modelling results in TJs. It also supports licensees and qualification bodies to assess modelling results if they are used in a TJ. The document includes descriptions of models and provides examples on how they can be used as part of substantiation of an inspection. Restrictions in using modelling and measures which should be applied are also addressed.
RP7	**Recommended General Requirements for a Body Operating Qualification of Non-Destructive Tests**
	RP7 provides guidance on the minimum criteria that a body operating qualification of NDT should follow if it is to be recognised as impartial, independent of operational pressures, competent and reliable. Three types of QB are considered within this RP: ▪ Type 1: A QB which is an independent third party organisation;

	▪ Type 2: A QB which is an independent part of the utility's organisation set up on a permanent or long-term basis; ▪ Type 3: An ad-hoc QB set up for a specific qualification. RP7 is mainly intended to provide guidance on the requirements for qualification bodies with a permanent organisational structure (types 1 and 2). Ad-hoc qualification bodies (type 3), being more temporary and inspection-specific in nature, will generally be established in a less formal way. However, many parts of RP7 still provide useful guidance to those wishing to set up an ad-hoc QB.
RP8	**Qualification Levels and Approaches**
	RP8 is intended to provide guidance on the setting of qualification level and on determining the qualification approach based partly on this choice of level. The qualification level reflects the assurance required that the inspection will attain its objectives. This will largely depend on the safety significance of the component and the role of the inspection in assuring structural integrity. In practice, qualification can be done with varying degrees of complexity and cost. The way such work is carried out is defined in this document as the "qualification approach", and needs to take into account both the structural integrity significance and the difficulty of each specific inspection. The qualification approach determines to what extent the various aspects of qualification, i.e. TJ, open trials, blind trials etc., are included in a particular case.
RP9	**Verification and Validation of Structural Reliability Models and Associated Software to be used in Risk-Informed In-Service Inspection Programmes**
	Structural Reliability Models (SRMs) are commonly used to evaluate failure probabilities in the development of RI-ISI programmes. RP9 summarises the verification and validation requirements that a SRM and associated software should satisfy in order to be suitable for such programmes. These requirements are mainly based on the work performed within the NURBIM project.
RP10	**Personnel Qualification**
	RP10 is meant to assist those involved in the qualification of inspection personnel to meet the principal objective of personnel qualification, i.e. to ensure that those carrying out an inspection are appropriately trained, experienced and examined to ensure the inspection is applied correctly and effectively. RP10 provides detailed guidance on how to conduct personnel qualification, handle qualifications to be renewed, and defining the role and responsibilities of the parties involved.
RP11	**Guidance on Expert Panels in Risk-Informed In-Service Inspection**
	RP11 is meant to assist users of RI-ISI applications in how to form, prepare, conduct and facilitate an expert panel as a part of a RI-ISI process. It gives guidance on responsibilities, composition, planning, conduct and documentation of the expert panel.
RP12	**Strategy and Recommended Contents for Inspection Procedures**[2]
	The main objective of RP12 is to support licensees, qualification bodies and inspection vendors to produce and assess an inspection procedure. The document includes what and how the contents in an IP should be described. The appendices give examples of content of different types of procedures.

[2] RP12 is a new ENIQ RP and will become available in late 2019.

Definitions for commonly used terms in inspection qualification are given in the ENIQ Glossary of Terms [1]. This methodology document, the ENIQ Glossary and all ENIQ RPs can be downloaded from the NUGENIA website (www.nugenia.org) under Resources.

Contributors to Drafting and Editing of Issue 4

Mathew Amos	EDF-Energy	Great Britain
Chris Curtis	Inspection Validation Centre (IVC) (Wood)	Great Britain
David Duxbury	Rolls-Royce Submarines Plc	Great Britain
Ladislav Horacek	UJV	Czech Republic
Jeff Weed	CANDU Owners Group Inc. (COG)	Canada
Oliver Martin	European Commission – Joint Research Centre	European Commission

ABOUT NUGENIA AND ENIQ

NUGENIA is an international non-profit association under Belgian law established in 2011. Dedicated to the research and development of nuclear fission technologies, with a focus on Generation II & III nuclear plants, it provides scientific and technical basis to the community by initiating and supporting international R&D projects and programmes. The Association gathers member organisations from industry, research, safety organisations and academia.

The activities of NUGENIA cover plant safety & risk assessment, severe accidents, reactor operation, integrity assessment and ageing of systems, structures & components, development of fuel, waste & spent fuel management & reactor decommissioning, innovative light water reactor design & technologies, harmonisation and in-service inspection & their qualification.

The European Network for Inspection and Qualification (ENIQ) is a utility driven network working mainly in the areas of qualification of non-destructive testing (NDT) systems and risk-informed in-service inspection for nuclear power plants. Since its establishment in 1992 ENIQ has issued over 50 documents. Among them are the “European Methodology for Qualification of Non-Destructive Testing” and the “European Framework Document for Risk-Informed In-Service Inspection”. ENIQ is recognised as one of the main contributors to today’s global qualification guidelines for in-service inspection. ENIQ became Technical Area 8 of NUGENIA in 2012.

9 782919 313235