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QUALIFICATION PROCEDURE FOR THE ENIQ PILOT STUDY

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1. SCOPE

This document describes the qualification procedure that will be used for the ENIQ Pilot Study. The work follows the principles given in the first (ENIQ Report No 1, EUR 16139, 1995) and second issue (to be published) of the European Methodology for Qualification of Non-Destructive Tests.

2. DEFINITIONS

For the purposes of Task 2.2 the definition of terms given in the “Glossary of Terms and Standards Used in Qualification” - draft final report of 24 October 1995 will apply. This draft final report funded by the CEC DGXI under Contract Number ETNU/CT/94/0132-UK has been widely circulated within ENIQ.

3. GENERAL DESCRIPTION OF THE ENIQ PILOT STUDY

As mentioned under Scope above, the pilot study is carried out in accordance with the principles set out in the European Methodology Document. It aims to explore the way in which detailed procedures for qualification of inspection are developed from these principles. In doing this, the intention is also to provide evidence that qualification carried out in this way is satisfactory in terms of providing confidence that the inspection is capable of meeting the requirements imposed on it by an overall structural integrity safety case. Furthermore it is also the purpose to test the feasibility of the European Methodology. The way this will be achieved is by applying the general principles of the European Methodology to one specific example.

The example that was chosen for the pilot study is the qualification of an inspection of austenitic pipe to pipe and pipe to elbow welds. All aspects of the inspection will be qualified. The procedure and equipment qualification involve open trials on test pieces containing defects while that of the personnel is done through blind trials. In addition to practical trials, qualification also involves the production of a technical justification as required by the methodology document.

The inspection, which is qualified, is an automated one involving a scanner and digital flaw detector. The inspection procedure is produced specially for this exercise and is tailored to the particular requirements of this inspection.

Qualification involves a combination of satisfactory practical trial results and a convincing technical justification. In this way, the overall case for the inspection is a stronger one than could be provided by test pieces alone. If qualification reveals shortcomings in any

aspect of the inspection, modifications will be made and the qualification *must* be repeated.

Once the inspection has been qualified, it will be applied to a number of "real" components, some containing defects removed from operating reactors and others containing simulated defects but welded using the same materials and procedure as the qualification test pieces. The results obtained will be compared in detail to those in the qualification part of the pilot study. From this comparison, conclusions will be drawn about the value of qualification in providing confidence in the inspection.

As indicated above, two types of ISI components under test will be considered:

1. a first set for which the qualification test pieces replicate exactly the size, geometry and macrostructure;
2. a second set on which less information is available and for which the qualification test pieces doe not replicate in detail the size, geometry and macrostructure.

It will be interesting to compare the results obtained on these 2 different sets. It should be stressed that the first set of ISI assemblies is the most important one.

4. INPUT INFORMATION

4.1 Introduction

As clearly stated in the second version of the European Methodology document all necessary input information required to do the inspection qualification should be provided prior to the start of the inspection qualification. A separate pilot study document is devoted to the input information (ENIQ.PILOT(96)3). In this section the most important features of the input information are repeated in order that the qualification procedure document can be read as a stand-alone document.

4.2 Component selected for qualification

The components to be inspected are austenitic pipe to pipe and pipe to elbow welds. The parent materials are wrought 304/316 austenitic steel and the welds are GTAW/SMAW. The inner surfaces of the assemblies are counterbored adjacent to the welds and the weld roots are undressed. The weld crowns are ground (not of second set of ISI assemblies). Access is limited to the outside surfaces.

Details of the geometry of the qualification specimens are summarised below:

- Diameter Range: 320 - 406 mm
- Thickness Range: 13.5 - 28 mm

- Weld Method: manual GTAW and SMAW
- Weld Material: E308 and E316

Details of the 2 sets of ISI assemblies are summarised below:

1st set of ISI assemblies:
- Diameter Range: 320 - 406 mm
- Thickness Range: 25 - 28 mm
- Weld Method: manual GTAW and SMAW
- Weld Material: E308 and E316

The qualification test pieces are very similar to this 1st set of ISI test pieces.

2nd set of ISI assemblies:
- Diameter Range: 320 - 710 mm
- Thickness Range: 16 - 30 mm
- Base Material unknown, possibly E304
- Weld Method: unknown, possibly MMA
- Weld Material: unknown
- Weld crown: as welded (possibility to grind unlikely)
- Weld root: as welded

As already mentioned before the qualification test pieces doe not replicate in detail the size, geometry and macrostructure found in the 2nd set of ISI assemblies.

4.3 Defect situation

For the purpose of the pilot study the following defect situations are proposed:
- IGSCC in the parent material adjacent to the welds. These defects originate at the inner surface of the pipes and are parallel to the weld with a maximum skew of ±10°. Mean angle of tilt is 0° but because of the irregular and branched nature of IGSCC, can vary by ±10°.
- Thermal fatigue cracks in the weld metal. These may originate at the weld surfaces or at pre-existing manufacturing defects within the body of the weld. Such defects are parallel to the weld with a maximum skew of ±10°. Angles of tilt can vary between 0° and the fusion face angles up to 30°.

The discussion whether one has to deal with a postulated and specific defect situation is for the pilot study not relevant, although the case of the specific defects situation seems to be appropriate.

4.4 ISI objectives

The objective of qualification is to ensure that an inspection has the necessary capability and that it is highly likely in practice to detect *and* correctly sentence all defects exceeding a certain size. This size is usually based on fracture mechanics calculations and crack growth rates. A safety factor is then often applied to the calculated figure and the resulting size is referred to as the qualification size. For qualification of real plant items this size will be calculated as discussed above and will be one of the inputs to the qualification process. The pilot study, on the other hand, is intended to illustrate the process of qualification according to the ENIQ principles and so the precise method used to produce the qualification size is not important.

For the purpose of the pilot study, a hypothetical case was selected where defects, which exceed 50% of the wall thickness, are critical from a structural integrity standpoint. We have taken this also as the qualification size. To ensure that no defects of this size will escape detection *and* correct sentencing, the required performance levels are as follows (see document ENIQ.PILOT(96)3 for full details on logic behind it):

For pipe thickness < 20 mm

- Defects exceeding 25% of the wall thickness (T) are unacceptable and 100% detection is required.
- For defects between 3 mm and 25% T, the detection rate required is 80%.
- The maximum undersizing permitted is 25% T.

For pipe thickness > 20 mm

- Defects exceeding (50% T - 5 mm) are unacceptable and 100% detection is required.
- For defects between the above size and 3 mm, the detection rate required is 80%.
- The maximum undersizing permitted is 5 mm.

For all thicknesses

- Defects smaller than 3 mm are acceptable.
- RMS depth sizing error should not exceed 3 mm.
- RMS length sizing error should not exceed 20 mm.
- For defects sized above that at which 100% detection is required, there should be no false calls.
- For defects, which are sized below that at which 100% detection is required, false calls should not exceed 1 per 2 metres inspected weld.
- Accuracy in depth location should be such that the error in measuring the ligament to the nearest surface is less than 3 mm.
- Accuracy in circumferential location should be such that the maximum lack of overlap between the actual and reported defects should not exceed 10 mm.
- the aspect ratio of the defects should not be smaller than 1 to 1.

5. GENERAL APPROACH

The general principles that are followed for the qualification are given in the European Methodology document.

The qualification is the sum of the following items:

i) open test piece trials to verify whether the proposed inspection procedure and equipment meet the defined objectives;
ii) blind test piece trials to verify whether the whole of personnel, inspection procedure and equipment meet the defined objectives;
iii) Technical justification which involves assembling all evidence on the effectiveness of the test including previous experience of its application, laboratory studies, mathematical modelling, physical reasoning and so on.

The personnel qualification, which is done in a blind way, is separated from the procedure/equipment qualification which is conducted in a non-blind way for all aspects in order to identify exactly where any possible weaknesses lie.

An important characteristic of the non-blind qualification of procedure/equipment is that the obtained inspection result has to be explained and justified in full detail to the Qualification Body. For example for each of the indications which the inspection team finds the full proof of evidence for detection and sizing has to be presented and explained in detail to the Qualification Body. This includes presenting and explaining the relevant B- and C-scans.

The way technical justification and practical trials are combined and the weight attributed to each of them, will depend on the level/rigour of inspection qualification required but also on the strength of evidence provided by each component in order to meet the requirements for each specific case.

6. QUALIFICATION PROCEDURE

The qualification procedure should contain the following information:

- objectives of the inspection qualification
- qualification rigour/level
- technical justification
- way the technical justification, NDT procedure, NDT equipment and NDT personnel will be assessed
- details on how the practical trials both blind and non-blind will be conducted
- qualification test pieces and defects
- way the results of the qualification will be evaluated.

6.1 Objectives of the inspection qualification

The purpose of the qualification is to provide sufficient confidence that the inspection is capable of meeting the requirements imposed on it by an overall structural integrity safety case. The ISI objectives to be met were detailed in section 4.4.

6.2 Qualification rigour/level

For the pilot study the case is selected that the qualification is the sum of the following items:

i) technical justification
ii) open test piece trials to verify whether the proposed inspection procedure and equipment meet the defined objectives
iii) blind test piece trials to verify whether the whole of personnel, inspection procedure and equipment meet the defined objectives.

The qualification will be considered as successful only if the requirements are met for the 3 different items: technical justification, non-blind trials and blind trials.

6.3 Technical justification

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

1. to overcome these limitations by citing all the evidence which supports an assessment of the capability of the inspection system to perform to the required level and hence provide a better defined confidence in the inspection,
2. to provide a technical basis for the selection of the essential parameters of the inspection system and their valid range,
3. to complement and to generalise any practical trials 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,
4. to provide a technical basis for designing efficient test piece trials.

One of the key roles of technical justification is to demonstrate why the test piece results, if good, would equally well have been obtained if the defects in the test pieces had been different from the particular ones incorporated but were still within the defect specification. In this way, the overall case for the inspection is a stronger one than could be provided by test pieces alone. If qualification reveals shortcomings in any aspect of the inspection, modifications will be made and the qualification must be repeated.

The technical justification comprises a mixture of experimental evidence and theoretical assessment as appropriate. Experimental evidence arises from previous qualifications from feasibility studies and industrialisation trials, round robin trials such as PISC, experience, where available through destructive examination, from operation of plant or laboratory evidence relating to features such as cladding, defect responses and so on. Sometimes theoretical assessment is needed to relate experimental evidence from similar tests to the actual situation. Theoretical assessment can also provide independent evidence on the adequacy of the proposed test.

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 few, the essential parameters, will indeed have a significant influence on the inspection outcome. These essential parameters have to be identified in the technical justification and the boundaries between which they can vary must be defined.

The contents of a technical justification for an austenitic component as the one studied in the pilot study are as follows:

1. introduction
2. description of the input data as received from the plant operator (component to be inspected, defects to be detected and sized, etc.)
3. short description of the NDT procedure and NDT techniques used
4. identification and discussion of the influential parameters; selection of the essential parameters and conclusions on the acceptable range of variation and on aspects to be introduced in the practical trials
5. evidence available to support the effectiveness of the NDT procedure and techniques selected:
   - evidence to demonstrate that the volume to be inspected is adequately covered during inspection; if the macrostructure of the welds to inspect is known results of ray tracing modelling can be used as supporting evidence that the volume to be inspected is indeed covered
   - evidence to show that the inspection is capable of detecting and sizing the defects of concern:
     * specific experimental evidence directly applicable to the specific case:
       - previous qualifications on similar components
       - development exercises on practice test pieces which have the same macrostructure as the components to be inspected in service
       - field experience
     * general experimental evidence which supports the capability of the NDT techniques chosen: for example on the capabilities of detection and sizing techniques in general because they were also used in round robin trials such

as PISC (relevance of the evidence to the particular case has to be demonstrated).

6. Justification of the choice of the qualification test pieces and the introduced qualification defects:
   - issues which will have to be justified are:
     - choice of qualification defects: in general the concept of “limit case” defects related to the specified defect situation will be very useful
     - choice of test pieces: if simplified geometries were used it will have to be shown that the results obtained on these simplified test pieces would equally well have been obtained on the real, more complex, components.

   This part of the technical justification will have to be written by the qualification body.

It is anticipated that for austenitic welds, the technical justification will not be strong enough in order to reduce significantly the number of test piece trials. Therefore, test piece trials are an important element of the qualification procedure.

6.4 Way the NDT procedure, equipment and personnel are assessed

6.4.1 General

The NDT procedure and equipment are assessed through technical justification and non-blind trials. An important characteristic of the non-blind qualification of procedure/equipment is that the obtained inspection results have to be explained and justified in full detail to the qualification body. For example for each of the indications which the inspection team considers as a defect the full proof of evidence for detection and sizing will have to be presented and explained in detail to the qualification body. This includes presenting and explaining the relevant B- and C-scans.

The personnel qualification is done in a blind way. The purpose of the blind trials is to verify that the inspection procedure, previously qualified during open trials, is correctly applied by the NDT inspector in the industrial environment corresponding to the real inspection. The inspection personnel participating in the blind trials should have been certified previously along the national NDT personnel certification scheme, as defined in the NDT procedure.

6.4.2 Practical organisation

As discussed in document ENIQ.PILOT(95)2 with as title “QA programme for the ENIQ pilot study”, the role of vendor is played by JRC Petten and that of the qualification body by Task Group 2.2. Table 1 gives more details on the responsibilities during the inspection and qualification part of the pilot study.

Table 1: Distribution of the tasks in the ENIQ pilot study for the qualification of the NDT equipment/procedure/personnel

Task	Responsible
Make available NDT equipment	JRC Petten
Preparation NDT procedure	JRC Petten
Preparation technical justification	JRC Petten + Chairman Task Group 2.2
Assessment of NDT procedure	Task 2.2 Assessment Group, composed of members of Task Group 2.2
Assessment of technical justification	Task 2.2 Assessment Group, composed of members of Task Group 2.2
Invigilation open trials	Invigilation team, composed of people of JRC Petten not involved in the inspection, possibly complemented with the Chairman of Task Group 2.2 and members of Task Group 2.2
Assessment of inspection results obtained during open trials	Technical audit group, composed of members of Task Group 2.2, having specific inspection experience
Invigilation blind trials	Invigilation team, composed of people of JRC Petten not involved in the inspection, possibly complemented with the Chairman of Task Group 2.2 and members of Task Group 2.2
Assessment of inspection results obtained during blind trials	JRC Petten + Chairman Task Group 2.2
Report on qualification part of pilot study integrating results from technical justification, open trials and blind trials	JRC Petten + Chairman Task Group 2.2

JRC Petten, complemented with the Chairman of Task Group 2.2, is responsible of producing the NDT procedure and technical justification.

Invigilation during the open and blind trials will be taken care of by those people of JRC Petten who have not been involved in the inspection, possibly complemented with the Chairman of Task Group 2.2 and members of Task Group 2.2.

The assessment of the NDT procedure, technical justification and results of the open trials will be done by expert groups composed of members of Task Group 2.2. JRC Petten will provide the secretariat for the meetings of these experts groups.

The Task 2.2 Assessment Group (TAG) has to assess the NDT procedure and technical justification, prior to the start of the practical trials. It is recognised that it is necessary to

separate the tasks of producing and assessing the technical justification and the NDT procedure. Therefore the TAG is composed of members of Task Group 2.2 who have not been involved in the preparation of either the NDT procedure or the technical justification. The actual composition is as follows:

Ph. Dombret	AIB-Vinçotte (B), Chairman
Ph. Benoist	CEA (F)
G. Bollini	Tecnatom (E)
R. Chapman	NE (UK)
J. P. Liétard	Tractebel (B)
T. Zetterwall	Swedish Qualification Body (S)

The technical audit group will have to assess in detail the inspection results obtained during the open trials. Because of the need to go in detail through the obtained inspection results the group should be composed of people having a large experience in practical inspections. The actual composition is as follows:

T. Zetterwall from the Swedish Qualification Body
Someone from CEA (through Ph. Benoist)
Someone from NE (through R. Chapman)

After the open trials a meeting will be organised between the technical audit group and the inspection team so that the inspection team can explain in full detail the obtained inspection results.

The Programme Manager of ENIQ, together with the Chairman of Task Group 2.2, is responsible for producing the different assessment reports and the report on the integration of the results of technical justification, open and blind trials.

6.4.3 NDT procedure and equipment qualification

The assessment of the NDT procedure and equipment is done by qualified assessors from the qualification body. The responsibilities defined in the framework of this pilot study are given in Table 1.

6.4.3.1 NDT equipment

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

- a paper study to determine the relevance of the standard or specifications to the specific case,
- proof of compliance with the standard(s).

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 include technical justification and open trials designed to measure the equipment essential parameters, identified during the analysis of the influential parameters. In this case the NDT procedure should identify the essential parameters and should specify allowable values and tolerances. During the open trials the practical application of the NDT equipment should be monitored. This will ensure that the equipment can be set-up and applied to components to be inspected and that its design is such as to minimise errors and ensure the quality of the ultrasonic data collected.

6.4.3.2 NDT procedure

The assessment of the NDT procedure will be done in different steps:

- First the NDT procedure must be fully written in a clear unambiguous way and provide useful step by step guidance for the user (preliminary assessment).
- Secondly it must be technically adequate to meet the requirements of the inspection (see section 4.4). The assessment of the technical capability of the inspection procedure will be the result of the combination of a review of the technical justification and the practical work carried out using the inspection procedure during open practical trials on test blocks.

The NDT procedure for detection, depth and length sizing is qualified through both open trials and technical justification.

i) Preliminary assessment of the NDT procedure

The assessment described below addresses the first of the two points above and will be an independent critical review to ensure that the procedure is written in a clear unambiguous way and contains suitable guidance for the user.

The procedure should be assessed using the checklist given in Appendix 1 to ensure that it contains all the points listed. It should also be assessed to determine whether it is written as a logical sequence of instructions. The assessors will produce a brief report providing comments on the procedure identifying any shortcomings or mistakes. This report will be incorporated in the overall procedure review document, which will also include the result of the technical assessment. If changes are needed, they will be incorporated by the group who wrote the procedure.

ii) Assessment of the technical justification and open trial results

a. Assessment of the technical justification

The assessment of the TJ is an independent review to determine the strength of the case for the capability of the inspection in relation to the ISI objectives of section 4.4. The assessors have to produce a brief report containing written comments on the technical justification as follows:

- How relevant to the inspection is the evidence in the TJ?
- How convincing is the evidence in support of the inspection capability?
- What are the relative roles in the case for capability played by the TJ and the practical trials?
- What results are needed from practical trials to complement the evidence in the TJ?
- Assessment of the analysis of the influential parameters leading to the identification of the NDT procedure essential parameters.
- Checking that all the NDT procedure essential parameters, which affect the outcome of the NDT significantly, and the range within which they can vary are specified and that they are, if necessary, considered in the practical trials.
- Relevance/quality of the data/information used to assemble the technical justification.

The checklist given in Appendix 2 can be used in assessing the TJ.

The TJ review will be included in the procedure review document along with the procedure assessment report mentioned above.

b. Assessment of the NDT procedure/equipment through open trials

The open trial is a practical demonstration using the procedure and equipment to inspect the test pieces. The objective is to collect sufficient ultrasonic data to demonstrate that the procedure and equipment are capable of meeting the defect detection and sizing performance claimed in the technical justification and corresponding, as a minimum, to the ISI objectives described in section 4.4. The open trial activities will be monitored by suitably qualified invigilators from the qualification body.

Appendix 3 describes in detail how the open trials will be carried out. This includes a requirement for checks to be made at certain designated stages that the requirements of the inspection procedure have been met. The principle that will be applied is that details of defects will be known to the inspectors. As already said

before full explanation of the obtained results will have to be provided by the inspectors to the qualification body:

- The origin of all recorded indications will have to be explained in full detail to the qualification body.
- The false call performance of the NDT procedure will be assessed by assessing the justifications, which are given for the indications not corresponding with any of the intended defects.
- Size measurement for example involves judgement and the reasoning, which led to the reported sizes, must be explained.

Prior to the commencement of the open trial, the inspection personnel will be briefed on the conduct of the qualification and safety.

6.4.4 Complementary qualification of the NDT personnel

Blind trials are used to verify that the NDT procedure and NDT equipment qualified during open trials are correctly applied by the inspection personnel in industrial conditions. The members of this team must not have been involved in the open trial unless different test pieces are to be used.

The composition of a typical inspection team is given in Table 2.

Table 2: Typical composition of an inspection team

Role	Required level	Main activity
Inspection leader	Level 3	Management/approval inspection report/ liaison with utility
Team leader	Level 3	Daily management of inspection team/data interpretation/production of inspection report
Ultrasonic operator	Level 2	Calibration/scanning/on-line data assessment
Manipulator operator	Level 1 or equivalent	Manipulator assembly

Each of the activities performed by the inspection personnel is important for the ultimate “success” of the inspection. Therefore, in principle each of the roles described should be subject to independent qualification during the blind trials. From a practical point of view, however, this is difficult to implement because the qualifications times would be excessively long and inspection activities overlap, making it difficult to account errors to individual people. The most important role is played by the team leader because he has the overall responsibility for the team and any failures must be attributed to him. That is why it seems appropriate that, although the team performance as a whole will be assessed in the trial, only the team leader will be formally qualified. It is the responsibility of the team leader to compose its team. The pre-qualification levels along a national

European certification scheme of the inspection team members are also shown in Table 2.

Therefore, for the purpose of the pilot study, the inspection leader on behalf of the whole inspection team will be qualified. Another way of looking at this is that for the purpose of the pilot study only 1 person, the team leader, will be “formally” qualified.

The blind trial activities will be monitored by suitably qualified invigilators from the qualification body.

Appendix 4 describes in detail how the blind trials will be carried out. This also includes a requirement for checks to be made at certain designated stages that the requirements of the inspection procedure have been met. The principle that will be applied for personnel qualification is that inspectors will only have the information about the defects that they would have in a real inspection. This would include the potential positions and types of defects to be expected but no information about their actual positions and types or their numbers and sizes. The time available for blind trials will also be constrained to that which would be available in a real inspection.

Prior to the commencement of the blind trial the inspection personnel will be briefed on the conduct of the qualification and safety.

6.5 Qualification test pieces and defects

6.5.1 Test piece requirements

In this section the test piece requirements will be described in order to carry out the test piece trials. As already discussed before the NDT procedure/equipment qualification is done through open trials and the complementary personnel qualification is done in a blind way.

6.5.1.1 Test pieces

The diameter of the qualification test pieces that are considered is 320 mm and 406 mm, which are representative of the smaller diameters as defined in the input information. The wall thickness that is considered for the qualification test pieces cover the range 12 to 30 mm covering the range as specified in the input information. Some of the test pieces are counterbored.

6.5.1.2 Defects

a) Open trials

The number of defect to be used during open and blind trials follows from the technical justification.

The purpose of the open trials is to verify that the NDT procedure/equipment proposed is fit for purpose. The number of defects during open trials should be large enough to allow assessing all necessary aspect of the NDT procedure/equipment. Therefore, the defect cases to be selected for the open trials are “limit” cases within the given defect specification and for the given inspection procedure, identified through the essential parameters analysis. If during open trials it can be shown that the inspection procedure is capable of correctly detecting and sizing these “limit case” defects for the given defect specification, then this should give sufficient confidence that the inspection procedure/equipment is capable of meeting its objectives also for the “average” defects, always for the given defect situation. Two defects per “limit” case” is considered to be the number to aim for during the open trials. The presence of some “average defect” cases during the open trials is also recommended.

The following cases are considered to be limit cases for the defect specification given and should be present in the open trials:

Detection IGSCC:

- small size
- maximum skew and tilt angle.

Depth sizing IGSCC:

- small size
- large size.

Detection fatigue defects:

- small size
- embedded fatigue cracks originating from pre-existing manufacturing defects oriented perpendicular to the surface.

Depth sizing fatigue defects:

- small size
- large size (no undersizing of critical defects permitted)
- fatigue defects originating from fabrication defects.

Small means here that the through-wall extent is smaller than a_{100}, which is the size above which 100 % detection is required during qualification, corresponding with 25 % through-wall extent in the pilot study. Large means a through-wall extent above a_{qual}, which is the qualification defect size, corresponding with 50 % through-wall extent in the pilot study.

b) Blind trials

The purpose of the blind trials is to verify that the inspection procedure qualified during the open trials is correctly applied by the inspector under industrial conditions. The defects for the blind trials are of the general type. As basis for the number of defects to be considered for the blind trials is the number of defects used in the framework of national personnel qualification schemes. It is proposed that the distribution of the through-wall extent of the defects to be used for the blind trials is as follows in order to have an equal distribution in through-wall extent of the defects present:

- at least 20 % below a_{100}
- at least 30% between a_{100} and a_{qual}
- at least 30 % above a_{qual}.

Hereafter follow some general remarks valid for all components:

- It is clear that the test pieces which have been used during the open trials, can not be used during the blind trials.
- In order to save time and money, it is proposed that the defects used for detection are also used for depth and length sizing.
- During the open and blind trials the inspection procedure will be judged separately for detection and location, depth sizing and length sizing.

6.5.2 Test piece quality checks

Test piece quality checks have to be carried out before practical qualification work commences, by personnel of the qualification body. The documentation provided by the different test piece manufacturers will be reviewed. The test pieces will be examined using X-rays and ultrasonics to ensure that the defects are as intended. It is also important to check that the volume around each defect does not contain significant indications that would make the defect unusable for qualification. It is expected that a certain number of assemblies will have to be examined in a non-destructive way.
A brief report containing the main conclusions of the quality checks will be included in the qualification dossier.

6.5.3 Confidentiality of test pieces for blind trials

All test pieces used for blind trials should be uniquely identified but all identification marks shall be concealed during qualification. When not in use for qualification purposes they should be inaccessible except to authorised staff of the qualification body. Likewise, manufacturing drawings, details of defective conditions and all documentary information relating to flaws should be secure except to authorised staff of the qualification body.

When test pieces are transported to the location of the different vendors adequate measures should be taken to guarantee that no unauthorised people have access to the test pieces used for blind trials.

The inspection people involved in the blind trials will have no knowledge of the defects introduced prior to the inspection.

All blind trials and written personnel examinations should be invigilated continuously. Steps should be taken by the qualification body to ensure 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.

6.6 Way results of the qualification will be evaluated

6.6.1 Combination of technical justification with results of open and blind trials

The NDT procedure and NDT equipment are qualified using technical justification and open trials. The additional personnel qualification will be done by means of blind trials, thereby using the inspection procedure and equipment qualified during the open trials. This was discussed in great detail in section 6.4.

The separation of the personnel qualification from the inspection procedure and equipment qualification will allow determination of exactly which part is to be blamed in the event of failure.

In the present case of a difficult stainless steel inspection the technical justification is mainly used as a support and guide to the open and blind trials to add further confidence, as discussed in this document, that the inspection procedure is fit for purpose. In addition, it will be used to ensure that good practical trial results were not obtained by chance.

6.6.2 Open trials

The inspection team will carry out the inspection and produce ultrasonic data records from which they will deduce the required defect information. They should record their results on the appropriate forms given in the procedure. These should be submitted together with the ultrasonic data records and the reasoning which produced the results to the qualification body for evaluation.

The results and ultrasonic data records will be compared with the definitive defect data to evaluate the performance of the procedures and equipment. This evaluation will be carried out interactively with the inspection team.

During the open trials the inspection procedure will be judged separately for detection and location, depth sizing and length sizing.

The inspection performance to be achieved is defined as follows:

- all the ISI objectives as defined in Section 4.4
- inspection results for detection, depth and length sizing will have to be explained and justified in full detail to the qualification body using thereby all necessary information. The minimum information required is as follows:
  - detection: all necessary plots showing the indication and the reasoning used to consider the indication as a defect;
  - false calls: all necessary plots showing indications which did not correspond with the intended defects and explanation why these signals occurred;
  - depth sizing: all necessary plots to explain which signals were used to determine the depth of the indication and the reasoning for this decision;
  - length sizing: all necessary plots to explain which signals were used to determine the length of each of the indications considered as defect and the reasoning for this decision.

Reasons for not qualifying the inspection procedure during the open trials can be the following:

- ISI objectives not met
- ISI objectives met but no satisfactory explanation/justification on obtained results
- ISI objectives met but departures from the written inspection procedure.

The qualification body will have to evaluate the obtained inspection results and will have to assess whether results obtained meet the requirements as described in this section. One can distinguish 2 different types of ISI objectives: the ones related directly to structural integrity, such as the detection requirements for the defects larger than 50 % through-wall extent, and the ones not related directly to structural integrity such as for example the RMS error requirement for depth sizing. All ISI objectives directly related to

structural integrity should be met. If some of the ISI objectives, not directly related to structural integrity (for example RMS error for depth sizing is 4.0 mm instead of lower than 3.1 mm) are not met, then the qualification body will have to make a proposal to the utility whether or not the NDT procedure/equipment can be qualified and justify its proposals.

The qualification body prepares a report on the conduct and results of the open trials, justifying all it conclusions. This report will be part of the Qualification Dossier.

The way this will be organised practically for the pilot study is described in section 6.4.2.

6.6.3 Blind trials

The inspection performance to be achieved is defined as follows:

- all the ISI objectives as defined in section 3.2 of this document,
- inspection results for detection, depth and length sizing will have to be reported fully along the NDT procedure qualified during open trials.

Reasons for not qualifying the inspection procedure during the blind trials can be the following:

- ISI objectives not met
- ISI objectives met but departures from the inspection procedure qualified during the open trials.

The inspection team will carry out the inspection and produce ultrasonic data records from which they will deduce the required defect information. They should record their results on the appropriate forms given in the procedure. These should be submitted together with the ultrasonic data records and the reasoning which produced the results to the invigilation team for evaluation.

The results and ultrasonic data records will be compared with the definitive defect data to evaluate the performance of the sizing procedure and the personnel. During the blind trials the inspection team will be assessed separately for detection and location, depth sizing and length sizing.

The qualification body will have to evaluate the obtained inspection results and will have to assess whether the results obtained meet the requirements. The same remark concerning meeting the ISI objectives is valid as the one made for the open trials. The qualification body will prepare a report on the conduct and results of the blind trials. This report has to be part of the Qualification Dossier.

The way this will be organised practically is described in Section 6.4.2.

APPENDIX 1

Checklist for the assessment of the inspection procedure

The procedure should be checked to ensure that it covers the following aspects:

1. Examination technique, including angles and modes of wave propagation in the material and directions, maximum speed, and extent of scanning.

2. Component details, including:
   - weld types and configurations to be examined
   - dimensions, materials and product form
   - scanning surface(s) and surface finish requirements.

3. List of essential variables

4. Inspection equipment list including the following items:
   - make and model of ultrasonic flaw detection instrument
   - ultrasonic probes, including for each type, angle, frequency and crystal size
   - size(s) and configuration(s) of welds and shoes
   - couplant
   - ultrasonic probe cable type, lengths and number of connectors.

5. Inspection equipment checks/verifications

6. Inspection equipment set-up

7. Techniques of calibration and of establishing scanning sensitivity levels, including instrument controls to be used and acceptance standards for calibrated conditions

8. Design of:
   - calibration block(s)
   - probe characterisation block(s)
   - reference block(s).

9. Scanning details

10. Data to be recorded and method of recording

11. Methods of data interpretation

12. Presentation of results

13. Checklists

14. Personnel qualification requirements and responsibilities

15. Reference documents

APPENDIX 2

Checklist for the assessment of the technical justification (TJ)

1. General

   1.1 Is the document clearly identified as the TJ?

   1.2 Does it make clear which inspection it is supporting?

   1.3 Are the appropriate defects and the tolerances for detection sizing and location identified?

   1.4 Are all the procedures to be qualified identified and considered in the TJ?

2. Essential parameters

   2.1 Is the complete list of essential parameters given?

   2.2 Is a valid justification given why these parameters among the influential ones are considered to be essential (references, quality of the information)?

   2.3 Are the boundaries indicated between which they can vary?

3. Capability/inspection performance

   3.1 Does the TJ claim the inspection has the required capability?

   3.2 Does the TJ make clear what is understood by the required inspection performance capability?

   3.3 Does the evidence produced demonstrate that the procedures achieve the required inspection performance?

4. Detection

   4.1 Does the TJ conclude that the procedures will detect the defects of structural concern?

4.2 Is the volume coverage complete?

4.3 Are all the detection levels and other test parameters clearly and unambiguously stated?

4.4 Examining the evidence for detection in the TJ:
- If experimental, is the whole range of defects(1.3) covered?
- If theoretical, are the models appropriate, adequate and verified?
- If technical judgement is used, is this made clear?

4.5 Are any uncertainties and limitations identified?

4.6 Is any work prepared to reduce the areas of uncertainty, and if so, when are the results likely to be available?

5. Sizing and location

5.1 Does the TJ conclude that the procedure allows the defects to be located and sized within the tolerances (1.3)?

5.2 Is sufficient evidence presented to confirm the location and sizing claims?

5.3 Does the evidence adequately cover the full range of defects?

5.4 Has technical judgement been employed?

5.5 Are any uncertainties and limitation identified?

5.6 Is any work proposed to reduce the errors? When will it be reported?

6. Equipment

6.1 Are the standards, including tolerances, for the inspection equipment given?

6.2 Is it concluded that equipment which meets these standards and is used in accordance with the inspection procedures (1.4) will detect the defects (1.3)?

6.3 Does the evidence presented support this conclusion, and is it demonstrated that at least one of the probes, even at the extremes of the specification will still detect the defects (1.3)?

6.4 Is it concluded that the equipment which meets the standards and is used in accordance with the inspection procedure (1.4) will allow the defects to be located and sized within the tolerances (1.3)?

6.5 Does the evidence presented support the conclusion, and is it demonstrated that an appropriate combination of probes, even at the extremes of the specification will locate and size defects to within the tolerances (1.3)?

APPENDIX 3

Document to control open trials

Introduction

The open trial is a practical demonstration to qualify the procedure and equipment. The inspection vendor team consists of members of the JRC NDT department supplemented by inspectors with industrial experience. The inspection team is required to scan allocated inspection regions of selected test pieces to demonstrate the capability of the equipment and procedure to meet the requirements set out in the procedure guidelines for detection, length measurement, location and false calls. A principle that is applied is that operators applying the inspection have information about the defect positions and sizes. They are required to produce records from the inspection which substantiate the performance of the procedure and equipment for detection, size measurement and false calls.

The invigilation and assessment of the open trial activities is organised as discussed in section 6.4.2.

Scope

This document describes the important steps and responsibilities for preparation and control of the open trials. It is for the use of the qualification body overseeing the qualification.

Preparation for Open Trials

The documentation required for the open trials should be assembled by the qualification body.

This comprises the following:

- Inspection Procedure
- Qualification Procedure
- Equipment calibration and set-up requirements.

A designated area for the practical work will be set up. In general there will be two secure areas. The first for the qualification test pieces requires sufficient space for the inspectors to carry out the practical work safely. The second is the working area for the invigilation team who monitors the trials, issues and controls documentation and evaluates the inspectors' results.

Conduct of the Trials

The qualification body will give a short briefing to the inspection team on the conduct of the trials.

The qualification body will allocate inspection volumes on the qualification test pieces and provide details of the defect positions and sizes within the designated volumes.

The qualification body will establish a suitable time limit that will be imposed during the trials. The time used to complete the demonstration will be recorded as part of the qualification.

The inspection team will perform an ultrasonic examination of the allocated inspection volumes using the inspection procedures and equipment. The invigilation team will monitor that the procedures are accurately followed.

Any observed departures from the procedure or difficulties experienced by the inspection team will be recorded and evaluated for their effect on the outcome of the trials.

In assessing the equipment, the qualification body will pay particular attention to its performance in the open trials. The following features will be assessed:

- The equipment is that described in the procedure
- The probes are uniquely identified
- The probes cannot be mounted incorrectly in the scanner
- The coupling system provides for reliable performance
- The scanner covers the required areas without producing excessive probe lift off
- Any other features which can affect the outcome of the inspection.

The qualification body will maintain a logbook recording all activities carried out during the trial.

The technical audit group will assess the inspection results and will prepare a report on the conduct and results of the open trials, drawing conclusions. This report will be submitted to the members of Task Group 2.2 for comment and will be formally approved by the Programme Manager and the Chairman of Task Group 2.2. This report will be part of the Qualification Dossier.

APPENDIX 4

Document to control blind trials

Introduction

Blind trials are used to verify whether the inspection personnel applies correctly the already-qualified procedure and equipment. The inspection vendor team consists of members of the JRC NDT department supplemented by inspectors with industrial experience. The members of this team to be qualified must not have been involved in the open trial unless different test pieces are to be used. The blind trial activities are monitored by suitably qualified and/or experienced invigilators from the qualification body.

Scope

This appendix describes the important steps and responsibilities for preparation and control of the blind trials. It is for the use of the qualification body overseeing the qualification.

Preparation for Blind Trials

The documentation required for the blind trials should be assembled by the qualification body.

This comprises the following:

- Inspection Procedure
- Qualification Procedure
- Equipment calibration and set-up requirements
- Personnel records for members of the inspection team.

Prior to commencement of trials, the qualification body will check that the personnel have qualifications and experience which matches the requirement of the inspection procedure in this regard. They will also check that the equipment to be used is that specified in the procedure.

A designated area for the practical work will be set up. In general there will be two secure areas. The first for the qualification test pieces will require sufficient space for the inspectors to carry out the practical work safely. The second will be the working area for the qualification body who will monitor the trials, issue and control documentation and evaluate the inspectors' results.

Conduct of the Trials

The qualification body will give a short briefing to the inspection team on the conduct of the trials. The blind trials will be used to assess the personnel carrying out the inspection, though only the team leader will be formally qualified as discussed in Section 11.

The qualification body will allocate inspection volumes on the qualification test pieces. For personnel qualification, no defect information at all must be available to the inspectors as would be the case in a real inspection.

The qualification body will establish a suitable time limit that will be imposed during the trials. The time used to complete the demonstration will be recorded as part of the qualification.

The inspection team will perform an ultrasonic examination of the allocated inspection volumes using the inspection procedures and equipment. The qualification body will monitor that the procedures are accurately followed.

Any observed departures from the procedure or difficulties experienced by the inspection team will be recorded and evaluated for their effect on the outcome of the trials.

The qualification body will maintain a logbook recording all activities carried out during the trial.

The qualification body will assess the inspection results and will prepare a report on the conduct and results of the blind trials. This report will be submitted to the members of Task Group 2.2 for comment and will be formally approved by the Programme Manager and the Chairman of Task Group 2.2. This report will be part of the Qualification Dossier.

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JRC Petten
Institute for Advanced Materials
P.O. Box 2
NL – 1755 ZG Petten
The Netherlands

ABSTRACT

One of the major achievements of the European Network for Inspection Qualification (ENIQ), composed of European nuclear plant operators, service vendors, qualification bodies and manufacturers, was the approval of the European Methodology for qualification of non-destructive tests.

The first issue of this document was published in March 1995 and the second issue was published in February 1997. The ENIQ European Methodology document describes inspection qualification as the sum of the following items:

- practical assessment (blind or non-blind), conducted on simplified or representative test pieces resembling the component to be inspected;
- technical justification, which involves assembling all evidence on the effectiveness of the test, including previous experience of its application;
- experimental studies, mathematical modelling, physical reasoning (qualitative assessment) and so on.

In the European Methodology, only general principles are provided on how to do inspection qualification. It does not contain detailed guidelines of how to do inspection qualification for a specific component. That is why, within the framework of ENIQ, it was decided to conduct a pilot study in order to explore ways of how to apply the European Methodology allowing at the same time to test its feasibility for implementation.

In this document, the qualification procedure, which was used for the ENIQ pilot study on wrought stainless steel welds, is described.