

EUROPEAN COMMISSION  
DG-JRC – Institute for Advanced Materials  
Joint Research Centre

## **FINAL REPORT OF THE FIRST ENIQ PILOT STUDY**

December 1999

ENIQ Report nr. 20

EUR 19026 EN

Approved by the Steering Committee of ENIQ

Directorate-General  
Joint Research Centre

**Published by the  
EUROPEAN COMMISSION**

**Directorate-General  
Telecommunications, Information, Industries and Innovation**

**L-2920 LUXEMBOURG**

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Catalogue number: CD-NA-19026-EN-C

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## 1. INTRODUCTION

The European Network for Inspection Qualification (ENIQ) was formed in 1992 to develop a European approach to inspection qualification. The original membership of ENIQ included all the western European nuclear countries and this has now been expanded to include the Czech Republic, Slovakia and Hungary. ENIQ is controlled by a Steering Committee whose voting members are the utilities. The Steering Committee is also attended by experts from inspection vendors, qualification bodies and development organisations. The Steering Committee is supported by a number of Task Groups whose role is to carry out detailed implementation of projects identified by the Steering Committee. Because of the wide-ranging membership of ENIQ, each country having its own special technical, legal and regulatory requirements, it was not judged possible to develop a prescriptive approach to qualification. Instead, ENIQ produced a methodology setting out the principles which should apply to the way qualification is carried out and a framework for the way in which it should be organised [1-2]. The details of the organisation and implementation would be determined at the national level. To promote uniformity in the way qualification is carried out in Europe and to assist member countries in the development of detailed qualification systems, ENIQ is producing documents known as Recommended Practices [3-10]. These are advisory and contain information about the way in which different aspects of qualification can be developed and implemented.

To investigate the feasibility of the European Methodology in practice and to explore the detail of how it could be implemented, the Steering Committee decided that a pilot study should be carried out. This pilot study was also followed as observers by the members of the Task Force on inspection qualification of the Nuclear Regulator Working Group (NRWG). In 1996 this Task Force published a document in which the regulators describe a common position towards inspection qualification. It is emphasised that this document is in agreement with the general principles as given in the ENIQ methodology [11].

Note also that the IAEA published a report [12] on an approach for inspection qualification for countries operating WWER nuclear power plants. The approach described in this document is also in agreement with that given in the European methodology.

A number of detailed reports have already been written describing various aspects of the pilot study as different phases of the work were completed. These are listed in Section 6 of this report [13-17]. A number of other reports already exist in draft form and are in the process of being published [18-22].

The present report gives an overall picture of the pilot study, the results that have been obtained and the major conclusions. The pilot study has also revealed features of qualification that require further work and the report discusses this. In addition, the pilot study

showed the need for a number of Recommended Practices [3-10] on different aspects of qualification according to the ENIQ Methodology to clarify how it should be carried out. It also provided information on how these should be written.

Definitions of the qualification terms used in this document can be found in the second issue of the ENIQ glossary [23].

Section 2 of this report describes the pilot study and how it was organised. This includes details way of how the different roles of utility, inspection vendor, qualification body and regulator were performed. The conduct of the pilot study and the results obtained are given in Section 3. This section contains information about technical aspects such as the detail of the components, inspection methods, test pieces and inspection and qualification objectives. It includes the results of destructive examination. It also contains the assessment of the inspection results obtained during the qualification and ISI trials. The lessons learned from the pilot study are contained in Section 4 of the report. This section also includes the further work that was identified and describes the Recommended Practices produced as a result of the pilot study. Finally, Section 5 gives the major conclusions of the study.

## **2. REVIEW OF PILOT STUDY ORGANISATION**

One of the major objectives of the pilot study was to verify the feasibility of the inspection qualification principles as given in the European methodology.

During the pilot study the European methodology was applied to a very specific inspection example. The main steps of the pilot study consisted of qualifying the inspection of an austenitic pipe-to-pipe weld through a combination of technical justification and practical trials and then applying the qualified inspection to test pieces representing the actual component. The latter inspections simulate the in-service inspection. Comparison of the data obtained during qualification with that from the "ISI" provides evidence for the effectiveness of the qualification.

Two sets of ISI assemblies were inspected:

- the first set of ISI test pieces which is very similar to the qualification test pieces (materials used, structure and defects inserted)
- the second set of ISI test pieces which are cut-outs of nuclear power plants, containing service-induced defects on which the available information is limited

Two limiting situations are covered by these two sets of ISI specimens: the first where one has a lot of information on the ISI components and the second where less information is available. The scheme detailing the pilot study can be found in Figure 1.

The pilot study commenced in 1996 and, with one particular exception, has now been completed. The exception relates to the second set of ISI specimens that were removed from American BWRs because they contained IGSCC. As a result of the pilot study, it has now been appreciated that the defects in these specimens offer a valuable and unique opportunity to collect data about real IGSCC and its ultrasonic response. Consequently it has been decided to carry out extensive further measurements on these samples before they are sectioned. As a result, there is no precise knowledge of the nature or size of the defects in these particular test pieces. However, the first set of test pieces simulating ISI specimens were manufactured especially for the pilot study and these have been sectioned.

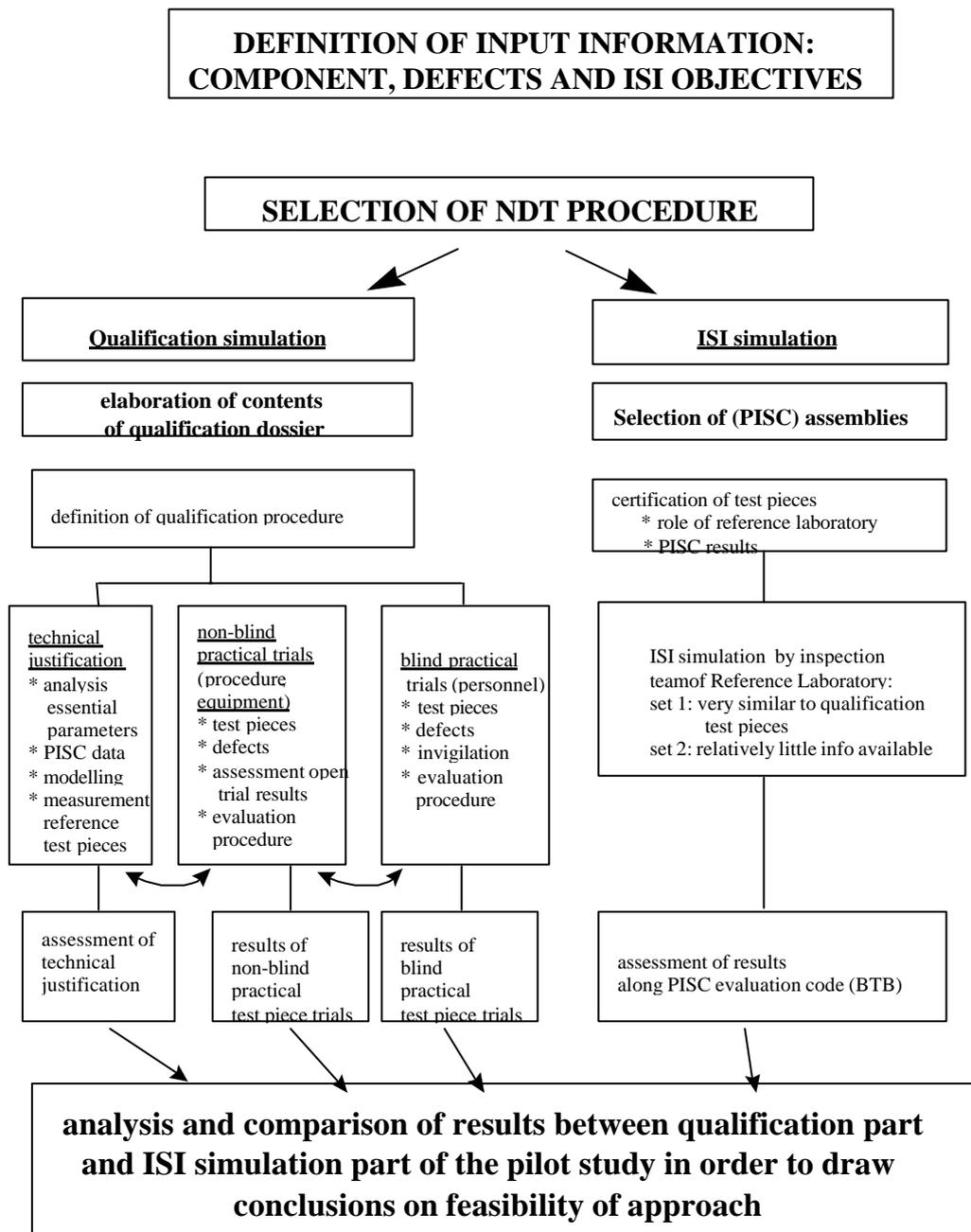


Figure 1: Scheme of the ENIQ pilot study

This pilot study was inevitably carried out under different circumstances from those which apply in a real inspection. In the latter, a number of parties is involved and they each have their own role to play in qualification. These parties include:

- The inspection vendor carrying out the inspection
- The plant operator which owns the plant and is hence responsible for the adequacy of the inspection
- The qualification body which carries out the qualification
- The safety authority who is responsible to the national government for plant safety.

The responsibilities of the different parties are set out in detail in the European Methodology document.

In this pilot study, the role of the different parties was assumed by different parts of ENIQ and the JRC. The equivalencies are as follows:

*The inspection vendor*, carrying out the inspection, was an inspection team from the JRC NDT Department. This team was supplemented by inspectors with industrial experience.

*The plant operator*

- Sets the requirements for ISI
- Sets the performance for ISI
- May assess the qualification procedure proposed by the qualification body and comment on it
- Either writes the inspection procedure or accepts one prepared by the inspection vendor
- Either prepares the technical justification or approves one prepared on the plant operator's behalf.
- Supervises all the inspection activities that affect performance, including receipt and verification of equipment, qualification of personnel, content of procedures and evaluation of results.

The first three of the above responsibilities have been discharged by the ENIQ Steering Committee. The final three, in this exercise, were taken by a group comprising the Chairman of ENIQ Task 2.2, the ENIQ Programme Manager and other JRC NDT staff who are not members of the inspection team.

### *The qualification body*

- Develops the qualification procedure
- Applies qualification according to this procedure, including NDT procedure assessment, technical justification assessment and practical trials
- Designs and produces test pieces
- Assesses and reports the results
- Produces the qualification dossier
- Issues qualification performance documents for certification
- Prepares a quality assurance programme.

In this pilot study, the role of the qualification body was played by staff of JRC Petten, who were not involved in the inspection, and ENIQ Task Group 2.2.

*The safety authority (or regulatory body)* who is to be responsible to the national government for plant safety. Its responsibilities will vary depending on the legal and regulatory requirements in each country. As already mentioned the pilot study was followed by the NRWG Task Force for inspection qualification, as observers. Two of their members followed the pilot study very closely and regular meetings were held to inform the regulators about the progress made with the pilot study.

A quality assurance programme was agreed which is described in reference [13].

## **3. CONDUCT AND OUTCOME OF PILOT STUDY**

### **3.1 INPUT INFORMATION**

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

1. full description of the component to be non-destructively tested
2. type and dimension of defects to be detected and/or sized, depending on the defect situation considered
3. objectives of the inspection qualification and the inspection performance (detection, sizing and location) to be achieved
4. the inspection procedure, equipment and personnel requirements

In this section the input information relevant to the pilot study is summarised. The input information is described in detail in reference [14].

### 3.1.1 COMPONENT

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. 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

A picture of the qualification test pieces used for this pilot study can be found in Figure 2.

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

First 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
- Weld crown: ground
- Weld root: as welded

Note that the qualification test pieces are very similar to this 1<sup>st</sup> set of ISI test pieces.

Second 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: ground
- Weld root: as welded

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



Figure 2: Picture of the qualification test pieces

### 3.1.2 DEFECTS

The defects which have been postulated for the pilot study are as follows:

- Intergranular stress corrosion cracks (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  $\pm 10^\circ$ . The mean angle of tilt is  $0^\circ$  but because of the irregular and branched nature of IGSCC, can vary by  $\pm 10^\circ$ .
- 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  $\pm 10^\circ$ . Angles of tilt can vary between  $0^\circ$  and the fusion face angles, say  $45^\circ$ .

Note that these defect descriptions were postulated for the purpose of the ENIQ pilot study, although they are considered to be realistic.

### 3.1.3 QUALIFICATION AND ISI OBJECTIVES

As stated above, 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 ( $a_{\text{qual}}$ ).

Because of its significance for plant integrity, it is essential that defects with true sizes equal to or exceeding the qualification size  $a_{\text{qual}}$  are detected and sentenced with 100 % certainty in the practical trials. This requirement will be met provided:

- (a) all defect with a *true* size exceeding  $a_{\text{qual}}$  are detected in the practical trials
- (b) all defects with a *measured* size exceeding  $(a_{\text{qual}} - \Delta a_{\text{max}})$  are sentenced as rejectable (in the trials and the actual inspection), where  $\Delta a_{\text{max}}$  is the maximum possible undersizing error

The second requirement ensures that detected defects having a true size bigger than  $a_{\text{qual}}$  are not sentenced as acceptable simply because they are undersized. It is implemented by setting the accept/reject boundary at  $(a_{\text{qual}} - \Delta a_{\text{max}})$ .

The qualification should therefore focus on:

- (a) establishing that defects with a true size of  $a_{\text{qual}}$  or larger can be detected;
- (b) establishing that the estimate of  $\Delta a_{\text{max}}$  is realistic.

An ENIQ recommended practice on how to determine qualification objectives from in-service inspection objectives is under preparation.

For the purpose of the pilot study the following was postulated concerning the different requirements. In order to establish (a) using test piece trials, it may be desirable to require 100% detection at a defect size,  $a_{100}$  say, which is smaller than  $a_{\text{qual}}$ . This provides some margin of comfort between the size  $a_{100}$  at which 100% detection is required in the qualification and the larger size  $a_{\text{qual}}$  at which 100% detection is required in the actual inspection. However, the difference  $(a_{\text{qual}} - a_{100})$  must be determined by judgement depending on the "margin of comfort" required. In some cases,  $a_{\text{qual}}$  may already have an adequate "comfort margin" built in, and then it would be appropriate simply to set  $a_{100} = a_{\text{qual}}$ .

In the pilot study, a figure of 50% of the wall thickness has been arbitrarily assumed as the qualification size ( $a_{\text{qual}}$ ). Furthermore, the margin  $(a_{\text{qual}} - a_{100})$  was also set in an arbitrary way equal to the maximum undersizing error  $\Delta a_{\text{max}}$ .

For qualification of real plant items these sizes will be calculated and defined 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.

The detailed requirements in the pilot study for detection, depth sizing, length sizing and false calls can be found in reference [14].

### **3.1.4 INSPECTION PROCEDURE, EQUIPMENT AND PERSONNEL**

The inspection procedure, which is in fact the object of the qualification procedure, has also to be known before the qualification starts. The description of the inspection procedure considers all aspects such as the techniques, equipment, decision steps used and personnel.

For the purpose of the pilot study an inspection procedure was developed taking into account:

- the results from the PISC III round robin trial on wrought-to-wrought austenitic welds
- measurements on reference specimens that had the same structure as the qualification test pieces

The inspection was an automated one involving a scanner and a digital flaws detector. Special attention was devoted to a detailed description of how the inspection results had to be interpreted in order to exclude as far as possible the judgement of the expert. This is especially important for the open trials for which the inspection results obtained have to be explained and justified.

The full inspection procedure can be found in reference [15].

### **3.2 QUALIFICATION PROCEDURE**

The qualification level adopted for the ENIQ pilot study should be very high. Therefore the qualification is the sum of the following items:

- i) 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.
- 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 if and only if the requirements are met for the three different components: technical justification, open trials and blind trials.

The assessment of the NDT procedure was done in 2 stages:

- ◆ First the NDT procedure must be 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. The assessment of the technical capability of the inspection procedure for detection and sizing is 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.

An important characteristic of the open qualification of procedure/equipment is that the obtained inspection result had to be explained and justified in full detail to the qualification body. For example for each of the indication which the inspection team considers as a defect the full proof of evidence had to be presented and explained in detail to the qualification body. Depth size measurements involve judgement and the reasoning, which led to the reported sizes, had to be explained.

This includes presenting and explaining the relevant B- and C-scans. Suitably qualified invigilators from the qualification body monitored the open trial activities.

Blind trials were used to verify that the inspection personnel are capable of using the already-qualified NDT procedure and NDT equipment.

The complete qualification procedure can be found in reference [16].

### **3.3 CONDUCT OF QUALIFICATION**

#### **3.3.1 ASSESSMENT OF THE TECHNICAL JUSTIFICATION**

The technical justification document contains three main chapters:

- analysis of influential/essential parameters

- evidence in support of the argument that application of the inspection system proposed allows the ISI objectives to be met (physical reasoning, PISC III Action 4 and measurements on reference test pieces)
- conclusions on test piece requirements

A Technical Assessment Group, composed of members of Task Group 2.2, was set up. The purpose of this task group was to assess the technical justification and the inspection procedure prior to the start of the test piece trials.

During the assessment of the technical justification the following issues came up:

- The need to elaborate a framework for the issues of essential/influential parameters.

The discussion on this issue led finally to the publication by ENIQ of Recommended Practice 1 on influential/essential parameters [3]. More details on how this issue evolved within ENIQ in the period 1997-1998 can be found in reference [18].

- The need to provide more information on the possible contents of the technical justification and how the technical justification could be used in the general context of inspection qualification.

As a result two recommended practices were published on the recommended contents of a technical justification and a strategy of how to use technical justification [4-5].

- The need to justify the decision/analysis process used in the inspection procedure.
- The need to ensure that the evidence in the technical justification is in agreement with the results obtained during the test piece trials.

The complete technical justification can be found in reference [17]. More details on the assessment of the technical justification can be found in reference [18].

The technical justification, which was produced for this inspection had to be complemented with test piece trials. In fact the test piece trials were an essential element in assessing the capability of the inspection system to meet the stated ISI objectives.

### **3.3.2 PRELIMINARY ASSESSMENT OF THE INSPECTION PROCEDURE**

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Prior to the start of the test piece trials the inspection procedure was assessed by the Technical Assessment Group, composed of member of ENIQ Task Group 2.2.

Attention was mainly devoted to the following issues:

- Correct definition of the essential procedure and equipment parameters (see also discussion on assessment of technical justification)
- Logical and unambiguous instructions, which have to be followed by the inspectors during the qualification and the inspection
- Clear and sufficiently detailed description of the analysis scheme used to evaluate the different indications

More information on this assessment can be found in reference [18].

### **3.3.3 TEST PIECE TRIALS**

#### **3.3.3.1 INTRODUCTION**

The test piece requirements for open and blind trials result from the analysis of the technical justification and the associated essential parameters.

The purpose of the open trials was to verify that the NDT procedure/equipment proposed was fit for purpose. The number of defects during open trials should be large enough to allow the assessment of all key aspects 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 also capable of meeting its objectives for “average” defects, always for the given defect situation. Two defects per “limit” case” was 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 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. The distribution of the through-wall extent of the defects to be used for the blind trials should be balanced taking into account the defect sizes as specified in the ISI objectives.

### 3.3.3.2 DESCRIPTION OF THE TEST PIECES USED

In total 9 test pieces were used for the qualification part of the pilot study. Four components were used for the first set of ISI components. Two different defect manufacturers (A and B) were used for the fabrication of IGSCC type defects. The same type of IGSCC type defects was present in the qualification test pieces and the 1<sup>st</sup> set of ISI simulation components. PISC type A defects were used to simulate the fatigue cracks in the qualification test pieces. The first set of ISI components contained one real fatigue crack. More information on the test pieces can be found in reference [20].

For the open test piece trials the following test pieces were used:

- Fatigue type defects: four different test pieces (ENIQ 3, ENIQ 5, ENIQ 6 and ENIQ 7) containing 15 artificial defects, simulating fatigue defects

The wall thickness of the test pieces varied between 15 and 28 mm. The diameter varied between 320 and 406 mm.

Eleven of the 15 defects were PISC type A defects. Some of these PISC type A defects were combined with manufacturing defects in agreement with the input information. Two defects were narrow slots simulating non-surface breaking fatigue cracks present in the weld. Two other defects were introduced by shrinkage buttering. The through-wall extent of the defects varied between 15 and 65 % of the wall thickness.

- IGSCC type defects: two different test pieces (ENIQ 1 and ENIQ 2) containing 4 realistic defect, simulating IGSCC (manufacturer A)

The wall thickness of the test pieces was 25 mm and the diameter was 320 mm. The 4 IGSCC type defects were manufactured using a method which is based upon introducing a branched fatigue crack in one half of the test piece, which is then welded with the other half of the test piece. The through-wall extent of these defects varied between 20 and 80 % of the wall thickness.

For the blind trials the following test pieces were used:

- Fatigue type defects: three different test pieces (ENIQ 4, ENIQ 7 and ENIQ 8) containing 12 artificial defects, simulating fatigue defects

The wall thickness of the test pieces varied between 17 and 28 mm. The diameter varied between 320 and 406 mm.

Ten of the 12 defects were PISC type A defects. The two remaining defects were narrow slots, simulating fatigue cracks embedded in the weld. The through-wall extent of the defects varied between 15 and 60 % of the wall thickness.

- IGSCC type defects: one test piece (ENIQ 9) containing 4 realistic defects, simulating IGSCC (manufacturer B)

The wall thickness of the test piece was 25 mm and the diameter was 320 mm. The 4 IGSCC type defects were manufactured using an implantation method. The through-wall extent of the defects varied between approximately 20 and 80 % of the through-wall extent.

For the first set of ISI trials the following test pieces were used

- Fatigue type defects: two test pieces containing one real fatigue crack  
One of the test pieces contained a real fatigue crack whereas the other test piece did not contain any defects. The wall thickness and diameter of both test pieces were 28 mm and 407 mm, respectively. The through-wall extent of the defect was about 50 % of the wall thickness.
- IGSCC type defects: two test pieces containing 7 realistic defects intended to simulate IGSCC (from both manufacturer A and B)  
One of the test pieces contained 4 IGSCC type defects similar to those manufactured for the open trials (manufacturer A), whereas the other test piece contained 3 IGSCC type defects similar to those manufactured for the blind trials (manufacturer B). The wall thickness and diameter of both test pieces were 25 mm and 320 mm, respectively. The through-wall extent of the IGSCC type defects varied between 20 and 90 % of the wall thickness.

### **3.3.3.3 CONDUCT OF TEST PIECE TRIALS**

The open test piece trials were conducted from 9/1/97 till 24/2/97. The inspection was performed by the following persons:

- Team leader and overview of inspection activities (data acquisition and data interpretation): B. Eriksen (level III ultrasonics), JRC Petten
- Data acquisition and data interpretation: M. Melbi (level III ultrasonics), ABB-TRC
- Data acquisition: G.-P. Battagin, JRC Petten

The data acquisition for the blind test piece trials was conducted from 25/2/97 till 21/3/97. The data analysis of the obtained inspection results was done in the period October-November 1997. The inspection was done by the following persons:

- Team leader and overview of inspection activities (data acquisition and data interpretation): B. Eriksen (level III ultrasonics), JRC Petten
- Data acquisition: G.-P. Battagin, JRC Petten

The inspection for the 1<sup>st</sup> set of ISI specimens was conducted in two stages. ENIQ 10, 12 and 13 were inspected in the period of from 24/3/97 till 27/3/97 and from 7/4/97 till 10/4/97. ENIQ 11 (due to the late delivery time) was inspected from 21/1/98 till 29/1/98. The inspection was performed by the following persons:

- Team leader and overview of inspection activities (data acquisition and data interpretation): B. Eriksen (level III ultrasonics), JRC Petten
- Data acquisition and data interpretation: G.-P. Battagin, JRC Petten

All inspection activities were continuously invigilated by H. Lohner (JRC Petten). A log book was kept in which all activities were noted. In Figure 3 a photograph is shown of the data acquisition performed during the test piece trials.



Figure 3: Picture of one of the inspectors and one of the invigilators during the test piece trials

### 3.3.4 MAIN RESULTS OF DESTRUCTIVE EXAMINATION

Within the framework of the ENIQ pilot study it was decided to do a full destructive examination of the test pieces containing IGSCC type defects and of some of those containing fatigue type defects. It should be stressed that this is normally not done for industrial qualifications. A complete defect catalogue with all macrographs can be found in reference [22].

Two different defect manufacturers were used for the fabrication of IGSCC type defects. Destructive examination gave the following information about the characteristics of these IGSCC type defects:

- The 4 defects in ENIQ test piece 1 and 2, used for the open trials, and the 3 defects in ENIQ test piece 12, used for the first set of ISI components (manufacturer A):
  - \* The branching is such that they can not be considered as IGSCC type defects but rather as branched fatigue cracks
  - \* Largest part of the defect is surrounded by weld material, which is more significant for the defects with a bigger through-wall extent
  - \* Crack tip of defect can be detected in isolation
- The 4 defects in ENIQ test piece 9, used for the blind trials, and the 4 defects in ENIQ test piece 10, used for the first set of ISI components (manufacturer B):
  - \* Manufacturer used an implantation technique which led to significant changes in the austenitic structure around the defects
  - \* Implant gives rise to ultrasonic signals which can be confused with crack tip signals
  - \* Defects are located in the weld area and not in the HAZ
  - \* Defects are not completely planar
  - \* Defects are not branched

Typical macrographs for the two different types of IGSCC defects considered in the pilot study are given in Figures 4 and 5.

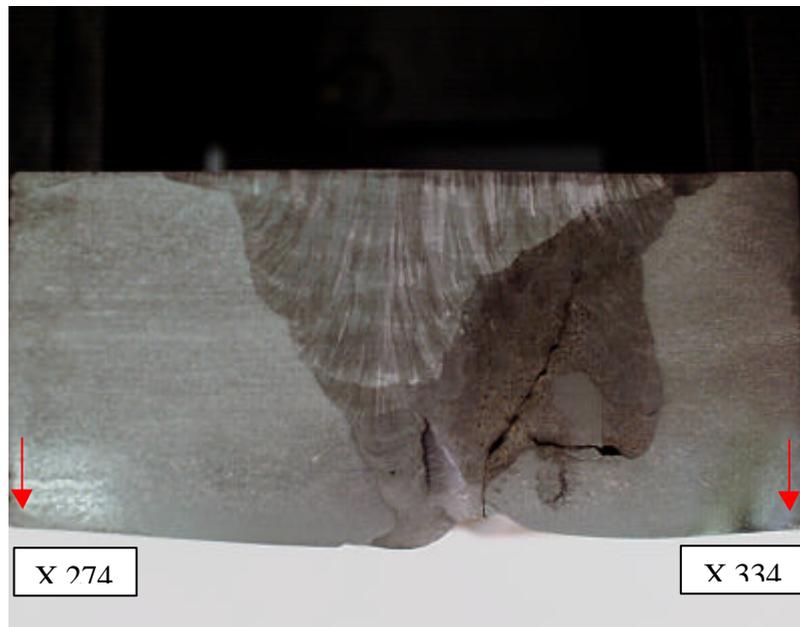


Figure 4: Macrograph of an IGSCC type defect made by manufacturer A (measures given in the macrograph are in mm)

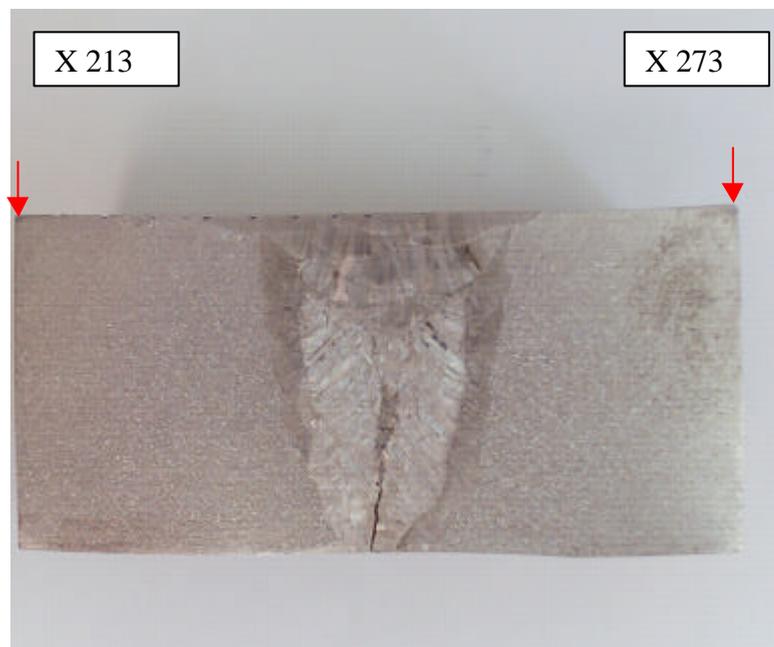


Figure 5: Macrograph of an "IGSCC" type defect made by manufacturer B (measures given in the macrograph are in mm)

No destructive examination was performed for the PISC type A defects, except for those that were combined with manufacturing defects. Destructive examination the depth and length

of the fatigue type defects introduced by shrinkage buttering in ENIQ test piece 6 to be measured exactly. Destructive examination showed that the fatigue crack introduced by mechanical loading in ENIQ test piece 11 (first set of ISI trials) consisted of two parallel parts of which one is longer than the other. Furthermore, it showed the presence of a buttering layer of about 1 mm. This layer is the remnant part of a buttering in which a starter notch for the fatigue crack has been introduced. This buttering was not completely removed after introduction of the fatigue crack and is clearly visible on the ultrasonic images.

These destructive examination results confirm the problems associated with the fabrication of realistic simulations of IGSCC type defects. Further work is needed in this area.

It should be stressed that these problems observed for the IGSCC type defects do not invalidate the approach followed for the ENIQ pilot study. Its purpose was to verify the feasibility of the European methodology and to explore ways of how to apply it. Firstly, the exact nature of defects does not matter as long as the same type of defects are present in the test pieces of the different stages of the project. The same type of "IGSCC" defects are present in the open and blind test pieces and also in the first set of ISI specimens. Secondly, there are the fatigue cracks which have been postulated as the second type of defects for the ENIQ pilot study and which do not present the problems discussed in this section. Similar problems would have arisen in any other type of qualification system and are not unique to the ENIQ methodology.

### **3.3.5 ASSESSMENT OF INSPECTION RESULTS**

#### **3.3.5.1 OPEN TEST PIECE TRIALS**

The inspection results obtained during the open trials were assessed in two ways. First there has been a verification that the inspection team was capable of explaining and justifying the inspection results obtained using the analysis/evaluation scheme as given in the inspection procedure. Secondly, there was an assessment to verify that the ISI objectives as defined in the input information were met (see next section). Only the first part of the assessment will be treated in this section.

An audit team, composed of selected members of ENIQ Task Group 2.2, reviewed the inspection results obtained during the open trials. The main emphasis was put on the capability of the inspection team to explain and justify the inspection results obtained using the inspection procedure previously approved by Task Group 2.2 of ENIQ. For that purpose

the inspection team showed the relevant A, B- and C-scans to the audit team and justified how it had reached its decisions on assessing the different indications.

The general opinion of the technical audit group was that the inspection procedure was acceptable for detection provided that clarifications were introduced in the inspection procedure concerning the following issues:

- the decision process as how to group the different indications present in the C-scans has to be explained in more detail
- in some cases it was noted that it was not possible to distinguish some of the mode converted signals obtained with the TRL probes from indications present along the whole circumference, which were either due to the weld root or the counterbore; it has to be clarified how this information is exactly used during the analysis of the inspection results

For depth sizing the following conclusions were drawn:

- TOFD proved to be impossible to use for defects located in or very close to the weld. For the defects which were located in the counterbore sufficiently far away from the weld TOFD worked correctly
- It was shown that the LL techniques as described in the inspection procedure worked quite well.

The team was able to explain clearly which signals were considered as the crack tip diffracted signals for depth sizing according to a well established analysis scheme.

A document explaining in detail how the inspection results have been analysed and explained according to the written inspection procedure was prepared by the inspection team after the audit [21].

A new version of the inspection procedure was issued after the open test piece trials in order to take into account the remarks of the audit team. In this version of the inspection procedure the instructions of how to interpret the inspection data for detection, depth and length sizing, are now unequivocal and correspond exactly to what was done during the open trials.

Whether it would be possible to change the analysis scheme as given in the inspection procedure after the open trials in an industrial qualification exercise is a matter to be decided between the different involved parties.

However, the purpose of this pilot study was to verify the applicability of the European methodology. One of the critical points for the correct application of open trials is exactly the ability to explain the obtained inspection results according to a written analysis scheme as given in the inspection procedure, without relying too much upon the opinion of the data analyst. That is why in this pilot study a lot of attention was devoted to a correct description of the analysis scheme to be used during the blind trials.

### **3.3.5.2 OVERALL ASSESSMENT**

In Tables 1 and 2 an overview is given of the extent to which the ISI objectives were met during the different phases of the ENIQ pilot study for the fatigue and IGSCC type defects, respectively. More detailed information on the assessments performed can be found in references [18-19].

#### Fatigue type defect

For the fatigue type defects all ISI objectives were met during the qualification part.

Although the detection and depth sizing criteria were met during ISI simulation that was not the case for length sizing and false calls:

- two false calls were made in the counterbore area of one of the ISI test pieces (ENIQ 11)
- the length of the fatigue crack was oversized significantly

The two false calls were made in ENIQ 11 can be attributed to the fact that the specific geometry of the counterbore of this test piece is completely different from that of the other test pieces. Its shape is very irregular and the surface is rough, which is probably the cause of reflections which were misinterpreted by the inspection team as defects. This is very clear when comparing the ultrasonic signals coming from the counterbore of ENIQ 11 with those observed on the other qualification test pieces.

The counterbore geometry of ENIQ 11 does not fall within the range/tolerance of counterbore essential input parameters which have been defined. The irregular shape or rough counterbore surface seem to be parameters which affect the inspection performance more significantly than the taper angle. It is clear that this type of counterbore geometry was not considered during the qualification trials.

The problem revealed here is hence not one of the European methodology but rather one of correct input information.

For the fatigue crack the inspection team reported a length of 125 as compared to the 73 mm measured by destructive examination. The error of 52 mm is relatively large. Further investigation after the ISI trials of the ultrasonic signal used to measure the crack length showed that the defect signal can be subdivided in 2 parts. There is a very clear indication, the length of which as measured by ultrasonics is 82 mm. However, next to this indication, along the weld centre line, there are a number of intermittent smaller indications which the inspection team grouped together with the large "defect" signal as one indication. The origin of these smaller indications is not completely clear but is probably associated with the defect manufacturing method used. They certainly cannot come from the weld root as this was removed when the buttering layer was machined away.

Note that the inspection results obtained for the fatigue type defect during the ISI trials are conservative and are not safety significant. The discrepancies observed between the qualification and ISI trials can be attributed on the one hand to an incorrect definition of the input information for the counterbore and on the other hand (probably) to the defect manufacturing method used to introduce realistic fatigue cracks.

#### IGSCC type defects

For the IGSCC type defects all ISI objectives were met during the qualification and ISI trials except for depth sizing.

For depth sizing no undersizing errors were made larger than 25 % of the wall thickness. However, the RMS error criterion was generally not met.

The fact that the RMS error criterion was not met can most probably be attributed to the defect manufacturing method used for the IGSCC type defects.

The IGSCC type defects of manufacturer A were both undersized and oversized. The fact that the corner of the branch may give rise to strong reflections may explain why some of the defects were undersized. The reason why some of the defects were oversized is not clear but may be related to the change in macrostructure due to the defect manufacturing method used.

In the case of the implanted IGSCC type defects (manufacturer B) the inspection team systematically oversized the depth of the defects because it measured the depth of the implant. Re-analysis of the inspection data after the trials showed that the crack tip diffracted signals could still be identified. The recalculated RMS error, based upon the depth deduced from these crack tip diffracted signals, is also given in Table 2.

It is important to stress that the obtained inspection results are consistent between the qualification trials and the first set of ISI trials. For example it was shown that there was a problem with depth sizing of the "IGSCC" type defects during the qualification trials and this was confirmed during the ISI trials. The results of destructive examination have shown later on that the problem identified for depth sizing was not due to the inspection procedure but to the manufacturing methods used for the IGSCC type defects.

Table 1: Overview of the extent to which the ISI objectives were met during qualification and ISI simulation for the fatigue type defects

Requirement	Technical justification	Open trials	Blind trials	ISI
100 % detection rate or defects exceeding 25 % TWE	Evidence given: <ul style="list-style-type: none"> <li>• PISC III trials</li> <li>• Limited laboratory trials</li> </ul>	OK (13 out of 13)	OK (11 out of 11)	OK 1 out of 1
80 % detection rate for defects between 3 mm and 25 % TWE	Evidence given: <ul style="list-style-type: none"> <li>• PISC III trials</li> <li>• Limited laboratory trials</li> </ul>	OK (2 out of 2)	OK (1 out of 1)	No such defects present
Maximum undersizing permitted is 25 % TWE or 5 mm	Evidence on depth sizing given	OK	OK	OK
RMS error for depth sizing < 3 mm	Evidence on depth sizing given	OK RMS = 1.9 mm	OK RMS = 1.6 mm	Absolute depth sizing error = 0.8 mm
RMS error for length sizing < 20 mm	No evidence given as amplitude drop methods are commonly used methods for length sizing	OK RMS = 7.4 mm	OK RMS = 6.0 mm	Absolute length sizing error is 62 mm
False calls	<ul style="list-style-type: none"> <li>• Not treated explicitly in technical justification</li> <li>• A lot of effort was devoted to optimising decision tree for detection/sizing during the open trials</li> </ul>	OK	OK	<ul style="list-style-type: none"> <li>- 2 false calls in counterbore area of ENIQ 11</li> <li>- geometry of counterbore area of ENIQ 11 not considered during qualification</li> </ul>

Table 2: Overview of the extent to which the ISI objectives were met during qualification and ISI simulation for the “IGSCC” type defects

Requirement	Technical justification	Open trials	Blind trials	ISI		
				all	ENIQ 10 (=blind)	ENIQ 12 (= open)
100 % detection rate for defects exceeding 25 % TWE	Evidence given: <ul style="list-style-type: none"> <li>• PISC III trials</li> <li>• Laboratory trials</li> </ul>	OK, 3 out of 3	OK, 3 out of 3	OK (5 out of 5)	OK (3 out of 3)	OK (2 out of 2)
80 % detection rate for defects between 3 mm and 25 % TWE	Evidence given: <ul style="list-style-type: none"> <li>• PISC III trials</li> <li>• Laboratory trials</li> </ul>	OK, 1 out of 1	OK, 1 out of 1	OK (2 out of 2)	OK (1 out of 1)	OK (1 out of 1)
Max. undersizing permitted is 25 % TWE or 5 mm	Evidence on depth sizing given: <ul style="list-style-type: none"> <li>• Laboratory trials</li> </ul>	OK	OK	OK	OK	OK
RMS error for depth sizing < 3 mm	Evidence on depth sizing given: <ul style="list-style-type: none"> <li>• Laboratory trials</li> </ul>	Not met RMS = 4.4 mm	Not met RMS = 4.6 mm (after blind trials) RMS = 1.8 mm (re-analysis of data)	Not met RMS = 3.8 mm	Not met RMS = 4.5 mm (after blind trials) RMS = 3.0 mm (re-analysis of data)	Met RMS error = 2.4 mm
RMS error for length sizing < 20 mm	No evidence given as amplitude drop methods are commonly used methods for length sizing	OK RMS = 19.6 mm	OK RMS = 11.6 mm	OK RMS error = 15.6 mm	OK RMS error = 14.0 mm	OK RMS error = 17.5 mm
false calls	<ul style="list-style-type: none"> <li>• Not treated explicitly in technical justification</li> <li>• A lot of effort was devoted to optimising decision tree for detection/sizing</li> </ul>	OK	OK No false calls	OK No false calls	OK No false calls	OK No false calls

## **4. LESSONS LEARNED AND REQUIREMENTS FOR FURTHER WORK**

### **4.1 INTRODUCTION**

The purpose of the ENIQ pilot study was to verify the feasibility of the European methodology. The pilot study has indeed confirmed that it is feasible to apply the European methodology satisfactorily. An important element leading to this conclusion is the fact that the results obtained in the blind and open qualification trials on the one hand and in the ISI trials, obtained on a set of ISI specimens made using the same welding methods as the qualification test pieces, on the other hand, were consistent with each other, independently of whether they were good or bad. The pilot study has also led to identify a number of areas where more detailed guidelines were desirable. The ENIQ recommended practices published as a result of the pilot study provide such guidelines on issues such as the essential parameters, technical justification, contents of the qualification dossier, the way open test piece trials should be conducted and modelling.

### **4.2 DESIGN OF THE PILOT STUDY**

Even before work started in earnest on the pilot study, a number of lessons were learned about the early stages of the qualification process.

#### **4.2.1 ESSENTIAL PARAMETERS AND INPUT INFORMATION**

The first lesson was the need to define all the information about the inspection to be qualified and other factors that could influence the outcome. Only when all relevant information about the component to be inspected, the inspection to be qualified and the equipment to be used is available is it possible for the qualification to proceed. The need to identify the parameters that affect the outcome of a particular inspection was recognised and led to considerable development of the basic concepts. Influential parameters were defined as those that are potentially of significance for the inspection method to be used. For a particular inspection, only some of the influential parameters are relevant and these were defined as the essential parameters for that inspection. It was recognised that the essential parameters fall naturally into three groups:

*Input parameters.* These parameters are the starting point of the qualification. They define the problem and include details of the component that can affect inspection

performance such as the size, geometry, material and so on. Also included are details of the defects the inspection is designed to detect and size. Again, the details required depend on the inspection method to be used but include information on defect position, orientation, roughness and size. The other parameters included in the input group relate to the required performance of the inspection. This includes requirements on defect detection rates at different defect sizes, sizing and positioning accuracy and so on. These inspection requirements must be translated into the requirements for qualification i.e. the detection rates, sizing accuracies and false calls permitted in practical trials.

*Procedure parameters.* Ideally, the procedure parameters are chosen to match the requirements of the input parameters. They define the key features of the inspection and govern the performance of the inspection in relation to the component and defect details defined in the input parameters. In practice, inspections have usually been developed to meet the requirements of codes or according to historic principles. Only rarely has a systematic process of defining component and defect details followed by procedure definition been followed. One of the early benefits of qualification is that it compels the logical process outlined above to be followed.

*Equipment parameters.* The equipment parameters are chosen to allow the procedure defined above to be followed to achieve the performance levels required. The input conditions may also have a part to play because they include information on any access or time restrictions that may influence the choice of equipment. Requirements relating to sizing or positioning accuracy in the input parameters may also influence the equipment choice.

All the parameters discussed above are one of two possible types. Some parameters are defined within a range of values. Defect orientation is one such parameter. Other parameters are given a fixed value with an allowed tolerance. Ultrasonic frequency is such a parameter. Qualification must show that performance remains at the required level over the full range for parameters of the first type and within the tolerance for the second type.

The understanding of essential parameters outlined above was included in a Recommended Practice that was issued in the course of the pilot study (RP1) [3].

#### 4.2.2 DEFINITION OF QUALIFICATION TARGETS

Amongst the input parameters discussed above are the performance targets that the inspection must achieve. These are defined in terms of the defects which must be detected and include the following:

- Defect size at which very high detection rates are required
- Defect size, lower than the above, at which some defined lower rate of detection is needed
- Defect position, orientation and roughness ranges
- Defect sizing and positioning accuracy in through-thickness and length dimensions
- Maximum acceptable levels of false calls

Once the ISI objectives, as defined above, are known, the performance required in qualification must be determined. The criteria for passing qualification are not, in general, the same as the ISI requirements because the number of defects that can be included in qualification is statistically very small for logistical reasons. In addition, a significant part of the confidence in inspection that arises from application of the ENIQ approach comes from the TJ. For these reasons, the outcome of qualification can never be expressed in terms of statistical probabilities. It is only possible to express confidence in a qualitative way. When practical trials are limited to a relatively small number of defects, any failures in detection or sizing capability that are revealed are highly damning but a positive result can never be conclusive by itself. However, a positive result, in combination with a powerful TJ that generalises the trials results and shows that equally good results would have been obtained over the full range of essential parameters, does allow high confidence to be expressed.

It follows from the discussion above that the required detection rate in a small sample for defects of a size requiring high confidence in detection will usually be 100%. Another factor that requires consideration is the size at which 100% detection is required. The starting point is the size emerging from structural integrity calculations. This is often reduced by a safety factor to give the size at which 100% detection in qualification is required. The danger if the safety factor is made too large is that the required performance may be unachievable and the inspection impossible to qualify at such sizes. Some judgement is therefore needed in selecting sizes for 100% detection in qualification. Similar judgements are needed in setting targets for sizing accuracy. Qualification is often used to establish the sizing accuracy, particularly the maximum

possible under-sizing. If this is added to all reported sizes when comparing them to the target size at the assessment stage of the inspection, it ensures that no defects of the target size will be wrongly assessed. However, if the maximum under-sizing target is too large, many innocuous defects could be reported as significant and unnecessary repairs could result. The target under-sizing for qualification must therefore be set realistically.

The need to develop qualification targets from the ISI targets as outlined above was recognised early in the pilot study and an RP (RP8) is under preparation to provide guidance [10].

#### **4.2.3 SUPPORT IN WRITING AND USING TECHNICAL JUSTIFICATIONS AND THE QUALIFICATION DOSSIER**

The feature of the ENIQ methodology that is central to the approach is the use of technical justifications. These can be used for a variety of purposes within qualification including justification of procedures, test pieces and inspection equipment. They can also be used to extend an existing qualification to new circumstances where geometry, material, defect requirements or equipment vary from the earlier qualification. The need to produce a TJ for the pilot study drew attention to the fact that TJs are unfamiliar to many who wish to use the ENIQ methodology. Two RPs were therefore written (RP3 and RP2) [4-5]. The first describes the use to which TJs can be put and suggests their content for each application. The second describes a suggested format and gives a detailed description of the different components of a TJ. The objective is to promote a common understanding of the purpose of TJs throughout Europe and to encourage their production in a consistent way. Adoption of a similar format would facilitate the assessment of TJs across national boundaries as well as encouraging their production in a technically satisfactory way.

A similar situation to that outlined above applies to the Qualification Dossier. This is the file of information that builds up as qualification proceeds. At the end of qualification, it provides the record of what was done and what results were obtained. If any other organisation such as a regulatory or third party body wishes to scrutinise the qualification details, the dossier would provide their source of information. Again, the concept is a new and unfamiliar one and experience in the pilot study suggested the need for an RP on the subject to define what might be included. This has been issued as RP4 [6].

## **4.3 CONDUCT OF THE PILOT STUDY**

### **4.3.1 PROBLEMS WITH AUSTENITIC COMPONENTS**

The components chosen as the subject of the pilot study were austenitic pipework welds. It was quickly realised when producing the TJ that qualification would have to rely heavily on the use of practical trials and less on the TJ than would be the case for ferritic components. This arises for a number of reasons:

Ultrasonic propagation through austenitic welds depends on the metallurgical structure of the particular weld. In general this will not be known at the outset of qualification. It is then necessary to produce test welds using the same welding procedure as the site welds and assume that the resulting structures will be the same as the site welds. If these contain deliberate defects they can be used to make a direct assessment of the inspection. An alternative is to section the test welds and to make measurements of the structure. The measurements can be used as input to a modelling programme that predicts for example the path of the ultrasonic beams to be used for the inspection. In either event, test pieces are needed to encompass the effects of weld structure. For the same reason, work already carried out on other austenitic welds will not be useful unless it can be established that their structures are similar to the ones in question. In general, this will not be possible.

The factors outlined above determined the way the pilot study was structured. Originally, the plan was to use the six American BWR specimens thought to contain real IGSCC as the "ISI" test pieces. However, it was realised that nothing is known about the way they were welded and the materials used. Consequently, it would have been impossible to produce qualification test pieces that had any relevance to the ISI specimens. It was therefore decided to produce a second set of ISI specimens together with the qualification test pieces using the same methods and materials. In this way, the pilot study includes the two extremes of what may occur in practice – complete ignorance or complete knowledge of the site weld procedure.

A further problem for austenitic welds is that validated models to predict ultrasonic response are not as readily available as they are for ferritic materials. This means that theoretical prediction of defect responses is not easy.

A consequence of the above discussion is that much of the information which is normally included in a TJ for a ferritic weld is not available for their austenitic counterparts and, as stated at the outset, the demonstration of inspection performance must rely much more on practical trials. This is the reason why ENIQ has proposed a second pilot study on ferritic materials. The objective will be to study the way in which modelling and parametric studies can reduce the need for full-scale qualification test pieces.

### **4.3.2 PROBLEMS OF DEFECT INCORPORATION**

The need to rely on test piece trials as discussed above led to production of qualification and ISI test pieces containing deliberate defects. The qualification test pieces included those intended for both open and blind trials. The defects of concern, as set out in the input information, include IGSCC and fatigue. Contracts were placed with a number of leading manufacturers of test pieces for blocks including both types of defect.

Destructive examination has shown that, while the simulated fatigue defects appear to be reasonable replicas of real fatigue, there are major problems with the corrosion defects. These relate firstly to the way in which the structure of the austenitic welds is disturbed by the defect incorporation process. This enables defects to be detected even if they themselves produce no signals. It also leads to the size reported by ultrasonics being that of the volume of disturbance rather than that of the defect. The second problem is that the defects bear little resemblance to real IGSCC and their value in qualification is questionable as a result.

We therefore have the situation in qualifying certain inspections of austenitic welds that we need to rely on test piece trials but defects of major concern in such materials cannot be realistically inserted. This is an area which requires much further work to resolve and a programme of research has been proposed by ENIQ in the light of the findings of the pilot study. It has been recognised that the set of ISI specimens removed from American BWRs are of potentially great importance in such a study since they contain real defects which can be used to provide information on defect response to NDT for comparison with inserted defects. Accordingly, it has been decided to postpone their destructive examination until the necessary measurements have been taken.

### **4.3.3 THE USE OF OPEN TRIALS**

A feature of the ENIQ Methodology for qualification is the use of open trials to qualify the procedure or equipment. This involves the use of test pieces where those applying the inspection know details of the defects. The benefit is that blind trials for personnel qualification then take place using already qualified procedures and equipment and the reason for any failures is much more apparent than when any one of the personnel, procedure or equipment may be at fault. The benefit of open trials in this way was confirmed in the pilot study. The open trials were also found to be of benefit in showing that the procedure was well-written and contained no ambiguities or inconsistencies by actually applying it in a controlled way.

It was realised in carrying out the open trials that there is a need for close definition of how these are to be carried out. For example, there is a need to assess how size measurement is carried out. The reasons why particular features of the echo signals were chosen for size measurement must be explained in a convincing way. If this is not done and rigorously assessed, there is a danger that knowledge of the defect sizes will allow suitable signals to be fitted to the data. As a result of experience in the pilot study in carrying out open trials, a Recommended Practice, RP5, on the conduct of open trials was written [7].

The final point about open trials is that, for the reasons set out above, they provide invaluable data to supplement the TJ.

### **4.4 RESULTS OBTAINED IN THE PILOT STUDY**

The purpose of the ENIQ pilot study was to verify the feasibility of the European methodology. Therefore it was important that the results obtained in the blind and open qualification trials on the one hand and in the ISI trials, obtained on a set of ISI specimens made using the same welding methods as the qualification test pieces, on the other hand, were consistent with each other, independently of whether they were good or bad.

In most cases it was demonstrated that the inspection personnel, procedure and equipment met the inspection and qualification objectives set. This was further confirmed by the results obtained in the inspection of the set of ISI specimens.

In the case of depth sizing of the IGSCC type defects it was not possible to meet the RMS criteria. This was the case during the open and blind trials and was confirmed during the ISI trials. The problems observed for depth sizing of the IGSCC type defects can be attributed to the defect manufacturing methods used. Here the qualification part of the pilot study was still successful in that it correctly highlighted the difficulty of achieving the desired RMS depth sizing accuracy.

There were two cases where the results between the qualification trials and the ISI trials were not consistent. The first case concerns the problems with the counterbore described in Section 3 of this report. The discrepancy observed between the qualification and ISI trials was due to an incorrect definition of the input information. This shows the need to identify all essential parameters for a particular inspection and to ensure that test piece design takes account of these. The second case concerns the length sizing problems observed for the fatigue defect, which could be attributed to the defect manufacturing method.

Finally it can be concluded that the results obtained in the framework of this pilot study show that the European methodology is a satisfactory basis for qualification. The consistent results obtained during qualification and ISI trials demonstrate this. The problems which were observed were not due to inherent weaknesses of the European methodology but could be attributed to differences in test piece features of significance to NDT from those of the real components to be inspected (incorrectly defined input information) and the specific defect manufacturing methods used. Such difficulties would also arise in other qualification methods using test piece trials.

This conclusion will be refined when destructive examination of the second set of ISI specimens is complete.

## **5. CONCLUSIONS**

5.1 The ENIQ methodology provides a satisfactory framework within which to develop detailed qualification schemes for particular components.

5.2 Support in the effective and consistent application of the ENIQ methodology is provided by ENIQ through a series of recommended practices, many prompted by the Pilot Study.

5.3 Further work is needed to explore the use of technical justifications in areas such as the use of modelling and parametric studies to reduce the number of full-scale test pieces in qualification.

5.4 Further work is needed to resolve the problems of incorporating real defects in test pieces, which is a problem for all qualification systems. This includes work on simulating real defects with artificial defects in order to avoid the need of introducing real defects in qualification test pieces.

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22. Results of the destructive examination of the ENIQ pilot study: defect catalogue, ENIQ Report 19, EUR 19024 EN, Published by the European Commission, Brussels-Luxembourg, 1999
23. Second issue of the ENIQ glossary, ENIQ Report 12, EUR 18102 EN, published by the European Commission, Brussels-Luxembourg, 1999

**APPENDIX : List of all pilot study reports**

<b>DOCUMENT NUMBER</b>	<b>TITLE</b>	<b>VERSIONS</b>	<b>STATUS</b>	<b>PUBLICATION AS OFFICIAL EC-DOC.</b>
ENIQ.PILOT(95)1	Guidelines for the development of the ultrasonic procedure for the ENIQ task 2.2 pilot study	21/12/95 29/02/96	Draft Draft	No
ENIQ.PILOT(95)2	QA programme for ENIQ Task 2.2 pilot study	21/12/95 27/02/96 10/06/96 22/10/96 29/11/96	Draft Draft Draft Draft Final Draft Final	Published as ENIQ report 8  EUR 18118 EN
ENIQ.PILOT(96)3	Description of the input data for the ENIQ pilot study	07/06/96 08/10/96 22/10/96 29/11/96	Draft Draft Draft Final Draft Final	Published as ENIQ report 7  EUR 18116 EN
ENIQ.PILOT(96)4	Measurements in order to define the procedure	See ENIQ.PILOT (96)9		Part of technical justification  Treated in ENIQ Report 10
ENIQ.PILOT(96)5	Inspection procedure for the ENIQ pilot study	18/11/96 18/12/96 06/02/97 25/04/97 10/09/97	Draft Draft Draft Draft Final Draft Final	Published as ENIQ report 11  EUR 18115 EN
ENIQ.PILOT(96)6	Equipment used for the ENIQ pilot study	See ENIQ.PILOT (96)5		Treated in ENIQ Report 11
ENIQ.PILOT(96)7	Qualification procedure for the ENIQ pilot study	10/06/96 03/10/96 29/10/96 29/11/96	Draft Draft Draft Draft Final	Published as ENIQ report 9  EUR 18117 EN
ENIQ.PILOT(96)8	Detailed description of the qualification test pieces  Part I: test pieces used for open trials  Part II: test pieces	25/04/97	Draft	Treated in ENIQ Reports 16 and 17

	used for blind trials			
ENIQ.PILOT(96)9	Technical justification pre-trials	18/11/96 07/02/97 25/04/97 15/07/97 27/7/1998	Draft Draft Draft Draft Final draft	Published as ENIQ report 10  EUR 18114 EN
ENIQ.PILOT(96)10	Post-trials Technical Justification			Treated in ENIQ Report 16
ENIQ.PILOT(96)11	Assessment of Technical Justification and procedure			Treated in ENIQ Report 16
ENIQ.PILOT(96)12	Results of non-blind practical trials of the pilot study	03/06/97	Draft	Treated in ENIQ Report 16
ENIQ.PILOT(96)13	Results of blind practical trials of the pilot study	27/11/97	Draft	Treated in ENIQ Report 16
ENIQ.PILOT(96)14	Assessment of the results on the qualification part of the pilot study (post-destructive examination)	11/03/98 20/10/99	Draft Final	Published as ENIQ Report 16  EUR 19023 EN
ENIQ.PILOT(96)15	Description of ISI assemblies			Treated in ENIQ Report 17
ENIQ.PILOT(96)16	Assessment of the ISI simulation part of the pilot study		Final	Published as ENIQ Report 17  EUR 19025 EN
ENIQ.PILOT(96)17	Approach for the assessment of the pilot study	11/06/96 08/10/96 07/01/97	Draft Draft Draft	Treated in ENIQ reports 16, 17 and 20
ENIQ.PILOT(96)18	Final report of the first ENIQ pilot study	20/10/99	Final	Published as ENIQ Report 20  EUR 19026 EN
ENIQ.PILOT(96)19	Illustration of the analysis/evaluation scheme used during the open trials	28/9/1998 16/9/1999	Final	published as ENIQ report 18  EUR 19028 EN

ENIQ.PILOT(99)01	Results of the destructive examination of the ENIQ pilot study: defect catalogue	3/5/99	Final	published as ENIQ report 19 EUR 19024 EN
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EUROPEAN COMMISSION

**EUR 19026 EN 38 pages**

Editors: P. Lemaitre, J. Whittle, R. Chapman, B. Eriksen and I. Iacono

Luxembourg: Office for Official Publications of the European Communities

1999 – 38 pag. – 21.0 x 29.7 cm

Physical sciences

EN

Catalogue number: CD-NA-19026-EN-C

Copies of this ENIQ report can be obtained by writing to the following address:

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## **ABSTRACT**

The present report gives an overall picture of the first ENIQ pilot study, the results that have been obtained and the major conclusions. The pilot study has also revealed features of qualification that require further work and the report discusses this. In addition, the pilot study showed the need for a number of Recommended Practices on different aspects of qualification according to the ENIQ Methodology to clarify how it should be carried out. It also provided information on how these should be written.

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