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

ASSESSMENT OF THE QUALIFICATION PART OF THE PILOT STUDY (POST-DESTRUCTIVE EXAMINATION)

December 1999 ENIQ Report nr. 16 EUR 19023 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

LEGAL NOTICE

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information.

Catalogue number: CD-NA-19023-EN-C

©ECSC-EEC-EAEC, Brussels – Luxembourg, 1999

Printed in the Netherlands

CONTENTS

1. SCOPE

This document describes in detail how during the ENIQ pilot study the technical justification and the inspection procedure were assessed. The assessment can be subdivided in 3 major parts:

- assessment of the inspection procedure and technical justification prior to the start of the practical trials
- open test piece trials for the procedure qualification
- blind test piece trials for the personnel qualification

It should be stressed that this exercise was a pilot study. Therefore, issues, which were not completely covered, as they would have been in a normal industrial qualification exercise, are mentioned specifically.

2. DOCUMENTS USED FOR THE ASSESSMENT

The documents under scrutiny are:

- ENIQ.PILOT(96)5: Inspection procedure for the ENIQ pilot study
  The relevant versions for this evaluation are the following:
  - version of 18 November 1996
  - version of 18 December 1996
  - version of 6 February 1997
  - version of 25 April 1997
  - version of 10 September 1997
  - final version published as ENIQ report 11 (EUR 18115 EN)
- ENIQ.PILOT(96)9: pre-trials technical justification
  The relevant versions for this evaluation are the following:
  - version of 18 November 1996
  - version of 7 February 1997
  - version of 25 April 1997
  - version of 15 July 1997
  - final version published as ENIQ report 10 (EUR 18114 EN)
- ENIQ.PILOT(96)12: inspection results obtained during the open trials
- ENIQ.PILOT(96)13: inspection results obtained during the blind trials
- ENIQ.PILOT(97)19: illustration of the analysis/evaluation scheme used during the open trials (ENIQ report 18, EUR 19028 EN, Published by the European Commission, Brussels-Luxembourg, 1999)

3. APPLICABLE DOCUMENTS

The following documents were used during the assessment:

- European methodology for qualification of NDT, EUR EN 17299, Published by the European Commission, Brussels-Luxembourg, 1997
- QA programme (first ENIQ pilot study), ENIQ Report 8, EUR 18112 EN, Published by the European Commission, Brussels-Luxembourg, 1998
- Input information (first ENIQ pilot study), ENIQ Report 7, EUR 18111 EN, Published by the European Commission, Brussels-Luxembourg, 1998
- Qualification procedure (first ENIQ pilot study), ENIQ Report 9, EUR 18113 EN, Published by the European Commission, Brussels-Luxembourg, 1998
- ENIQ.PILOT(96)8: Detailed description of the qualification test pieces
    - Part I: test pieces used for the open trials (draft of 25 April 1997)
    - Part II: test pieces used for the blind trials (under preparation)
- Results of destructive examination of the ENIQ pilot study: defect catalogue, ENIQ Report 19, EUR 19024 EN, Published by the European Commission, Brussels-Luxembourg, 1999

It is important to mention also the final report on the pilot study in which all the results achieved during the ENIQ pilot study are summarised (ENIQ Report 20, EUR 19023 EN). The assessment of the ISI simulation results is given in ENIQ Report 17 (EUR 19025 EN).

4. ASSESSMENT OF THE INSPECTION PROCEDURE AND TECHNICAL JUSTIFICATION PRIOR TO THE TEST PIECE TRIALS

4.1 INSPECTION PROCEDURE

4.1.1 VERSION OF 18 NOVEMBER 1996

4.1.1.1 MEETING OF 26 NOVEMBER 1996 OF THE TECHNICAL ASSESSMENT GROUP

A first version of the inspection procedure (version of 18 November 1996) has been distributed to a number of selected members of Task Group 2.2, the so-called technical assessment group (TAG). A meeting was held on 26 November 1997 where the inspection procedure was discussed in detail. The following people were present during this meeting:

Benoist Ph.	CEA (F)
Chapman R.	NE (UK)
Liétard J.P.	Tractebel (B)
Dombret Ph.	AIB-Vinçotte (B), chairman TAG
Crutzen S.	JRC Petten (Nl)
Lemaitre P.	JRC Petten (Nl)
Eriksen B	JRC Petten (Nl)
Melbi M.	ABB-TRC (S)

Furthermore also written comments were received from Ph. Dombret (AIB-Vinçotte), R. Chapman (NE) and T. Zetterwall/P. Karlsson (SQC). These written comments are given in Appendix 1.

The following general remarks were made on this submitted inspection procedure:

1. The way the calibration is done should be explained in more detail. Also the frequency of calibration should be mentioned. Calibration sheets with settings should be provided for each calibration.
2. The inspection procedure is not industrial because too many probes are used, especially for detection. After some discussion it was decided that this was not a big problem as long as the inspection procedure is described in a clear and unambiguous way. The main purpose of the ENIQ pilot study is to study the way of how to implement inspection qualification and not how to write an industrial inspection procedure. It is also the intention to parametrise the results, considering the different probes used.
3. The essential parameters and the limits/tolerance between which they can vary should be mentioned in the inspection procedure.
4. There is too much descriptive information in the inspection procedure. This should be deleted and possibly be moved to the technical justification.
5. The analysis phase is not described in sufficient detail. It is absolutely necessary to have a clear and unambiguous decision tree in the inspection procedure.
6. The qualification body has only to inform the vendor on ambiguities in the inspection procedure. It does not have to judge upon the validity of the inspection procedure.
7. If possible avoid to use mark names for specific NDT equipment (specific for the ENIQ pilot study)

A number of specific remarks were also made. These are also given in Appendix 1.

4.1.1.2 DECISION TREE FOR ANALYSIS OF THE INSPECTION RESULTS: RESULT OF THE DISCUSSIONS HELD AT THE STEERING COMMITTEE MEETING IN CADARACHE ON 11 AND 12 DECEMBER 1996

At the Steering Committee meeting of ENIQ held in Cadarache on 11 and 12 December 1996 a discussion was held on how the decision tree should be changed as a result of the comments made at the TAG meeting of 26 November 1996 in Schiphol.

A lot of effort was devoted to write a decision tree on how to analyse and evaluate the inspection data. However, because one has to deal with the inspection of austenitic welds it is not expected that it will be possible to anticipate all situations that might occur. A long discussion was held on this issue. It was stressed that if it had been possible to write down

a complete analysis scheme this would already have been implemented since a long time. It was also said that if it is not possible to explain the obtained inspection results along a logical evaluation scheme then this would make it very difficult to execute an inspection qualification with open test piece trials. At a certain moment it was even suggested not to consider the weld root region, as this is the area which would pose the biggest problems. This was not accepted because this is considered to be the most important region to inspect.

It was finally agreed to have at the end of the decision tree 3 different possibilities:

- indication is a defect
- indication is not a defect (and can be attributed to the geometry of the component)
- indication can not be evaluated satisfactorily using the decisions tree as given in the inspection procedure

The last option is added in order to identify clearly these cases where it is not possible to explain the obtained inspection results along the analysis scheme given in the inspection procedure. This is in agreement with the general principles of the European methodology that “black boxes” are not wanted and that no guessing should be done.

4.1.2 VERSION OF 18 DECEMBER 1996

A new version of the inspection procedure (dated 18 December 1996) was distributed to ENIQ Task Group 2.2. This document was discussed in detail at the Task Group 2.2 meeting held in Petten on 8 and 9 January 1997.

Following comments were made:

R. Chapman (NE, UK):

- specify calibration procedure for the LL probes
- time base variation should be ± 5% rather than ± 10%

Ph. Dombret (AIB-Vinçotte, Belgium):

- there are still some descriptive parts in the inspection procedure which should be deleted

Ph. Benoist (CEA, France)

- Although recognising that there was a considerable improvement with respect to the first draft he said that he had problems with some of the choices made especially related to the selection of the sensitivity and some of the decisions used in the decision tree for the analysis of the inspection results. He said that the document in its actual shape was indeed a clear set of instructions although he wanted first to study the revised technical justification, which should justify the decisions taken. Therefore he agreed to recognise the actual document as an inspection procedure but he did not want to express a judgement on the validity of this inspection procedure without the technical justification. P. Lemaitre answered

that it was the intention to issue the technical justification for the technical audit meeting at the beginning of February 1997.

T. Zetterwall (SQC, Sweden)

- He remarked that several sizing techniques were proposed in the inspection procedure. He asked whether all sizing techniques would be qualified also if one or more of them had actually not been used during qualification. It was agreed that this was something that was not possible in practice. However, having recognised the problem for the pilot study it was agreed that the report of the technical audit group would have to specify which techniques had been used during qualification and only these, if sufficient data were available, would be considered as qualified.

Task Group 2.2 agreed to approve formally the inspection procedure for use during the open trials.

4.1.3 VERSION OF 6 FEBRUARY 1997

This version contains some minor corrections, which were requested during the Task Group 2.2 meeting held in Petten on 8 and 9 January 1997.

4.1.4 CONCLUSIONS ON PRELIMINARY ASSESSMENT OF THE INSPECTION PROCEDURE

In the qualification procedure document a checklist is given to verify that the inspection procedure covers the following aspects. In Table 1 it is verified up to which extent the requirements in this checklist are met for the different versions of the inspection procedure considered.

Table 1: Verification of the checklist as given in the qualification procedure for the different versions of the inspection procedure

	Version 18/11/96	Version 18/12/97	Version 6/2/1997
Examination technique, including angles and modes of wave propagation in the material and directions, maximum speed, and extent of scanning	Covered	Covered	Covered
Component details, including: • Weld types and configurations to be examined dimensions • Materials and product form • Scanning surface(s) • Surface finish requirements	 Covered Covered Covered Covered	 Covered Covered Covered Covered	 Covered Covered Covered covered
List of influential/essential parameters	Equipment and procedure parameters partly covered	Equipment and procedure parameters partly covered	Equipment and procedure parameters partly covered
Inspection equipment list including the following items: • Mark and model of ultrasonic flaw detection instrument • Ultrasonic probes, including for each type, angle, frequency and crystal size, size(s) • Configuration(s) of probes and shoes • Couplant • Cable type, lengths and number of connectors	 Covered Covered Covered Covered Covered	 Covered Covered Covered Covered Covered	 Covered Covered Covered Covered Covered
Inspection equipment checks/verifications	Covered	Covered	Covered
Inspection equipment set-up	Covered	Covered	Covered
Techniques of calibration and of establishing scanning sensitivity levels, including instrument controls to be used and acceptance standards for calibrated conditions	To be clarified	Covered	Covered
Design of: calibration block(s) probe characterisation block(s) reference block(s)	To be clarified	Covered	Covered
Scanning details	Covered	Covered	Covered
Data to be recorded and method of recording	To be clarified	Covered	covered

	in more detail		
Methods of data interpretation	To be clarified	To be clarified	covered
Presentation of results	To be clarified	Covered	covered
Checklists	Not covered	Not covered	Not covered
Personnel qualification requirements and responsibilities	Covered	Covered	covered
Reference documents	Covered	Covered	Covered

During the preliminary assessment of the inspection procedure a number of weak points have been identified as discussed above. These have been corrected and the Task Group 2.2 approved the inspection procedure for use during the open trials.

4.2 TECHNICAL JUSTIFICATION

The technical justification document contains 3 main chapters:

- analysis of influential/essential parameters
- evidence in support to the fact that application of the inspection system proposed allows to meet the ISI objectives (physical reasoning, PISC III Action 4 and measurements on reference test pieces)
- conclusions on test piece requirements

4.2.1 ISSUE OF INFLUENTIAL/ESSENTIAL PARAMETERS

Most of the discussions in ENIQ on the technical justification were held on the issue of the influential/essential/fixed parameters in order to try to determine a general framework of how to treat these parameters.

The technical justification was submitted to the TAG for discussion at the meeting held in Schiphol on 26/11/96. The following general comments were received at that meeting:

- analysis/evaluation scheme has to be justified more
- there is the need to classify the essential parameters in several categories (without coming to a final conclusion)

The issue of essential parameters was discussed again at the TG 2.2 meeting held on 8 and 9 January 1997 in Petten. Main conclusions of that meeting can be summarised as follows:

- one should differentiate between essential parameters which are defined by situation (defect, component) and those which are set in order to meet the ISI requirements (NDT procedure)
- the parameters that are defined in the input information should not be considered as essential
- the parameters that can be dominated by calibration or setting of the equipment should not be considered as essential
- the chapter in which the issue of essential parameters is discussed should come before the chapter in order to allow to identify for which parameters the choices made have to be justified

A new issue of the technical justification (dated 7/2/97) was distributed to all TG 2.2 members. The written comments received showed clearly that the issue of the essential parameters had not yet found a satisfactory solution.

At the TG 2.2 meeting held in Petten on 14 May 1997 it was decided to consider 3 groups of essential parameters related to:

- the input information to be provided (defects, components, etc.)

- the inspection procedure
- the inspection equipment

At the meeting of the Steering Committee of ENIQ held in Petten on 6 June 1997 it was agreed to introduce besides essential parameters also fixed parameters. Furthermore there seemed to be an agreement on the whole concept of influential/essential/fixed parameters as given in the final version of the technical justification (dated 15/7/1997) which was approved by the Steering Committee of ENIQ via the written procedure.

At the Steering Committee meeting held in December 1997 in Petten it was agreed to write a recommended practice on essential/influential parameters. The discussion of this recommended practice re-opened the debate on the issue of fixed parameters. After 2 further Task Group 2.2 held in Brussels on 8/5/98 and in Petten on 28 and 29 September 1998 and a Steering Committee meeting held in Stockholm it was agreed to consider 2 types of essential parameters:

* Essential parameters to be fixed within a tolerance

As already mentioned before, many of the identified essential parameters can sometimes vary within a tolerance without affecting the outcome of the inspection. However, if they vary beyond that tolerance they may influence the outcome of the inspection. The choice of the settings of these parameters and, if applicable, the appropriate tolerance will have to be fixed, for example, in the inspection procedure. In the technical justification, it may have to be shown that the inspection is not affected as long as the value of these parameters remains within the tolerance specified. These parameters are called the “essential parameters to be fixed within a tolerance”. For this first category of essential parameters, it has to be ensured during qualification (technical justification and/or practical trials) that the selected settings of these parameters are within the tolerance as specified. The methods used to measure this first category of essential parameters should preferably be specified.

* Essential parameters covering a range

The values of this second category of essential parameters have to be specified with a certain range and during qualification, it has to be demonstrated that the ISI objectives can be met considering the full range specified. This can be done by either ensuring that the qualification (technical justification and/or practical trials) considers the full range specified, or by considering the limit/worst cases within the specified range of that particular essential parameter. The limit/worst cases used in this context always refer to the specific inspection situation and techniques considered. The number of essential parameters falling into this category will generally be small.

The classification of the essential parameters into these 2 categories will depend upon each specific inspection qualification case. However, it is expected that most of the essential parameters of the procedure and certainly those of the equipment group will fall in the first category of essential parameters (to be fixed with a certain tolerance). On the other hand, it is expected that most of the essential input parameters will fall in the second category.

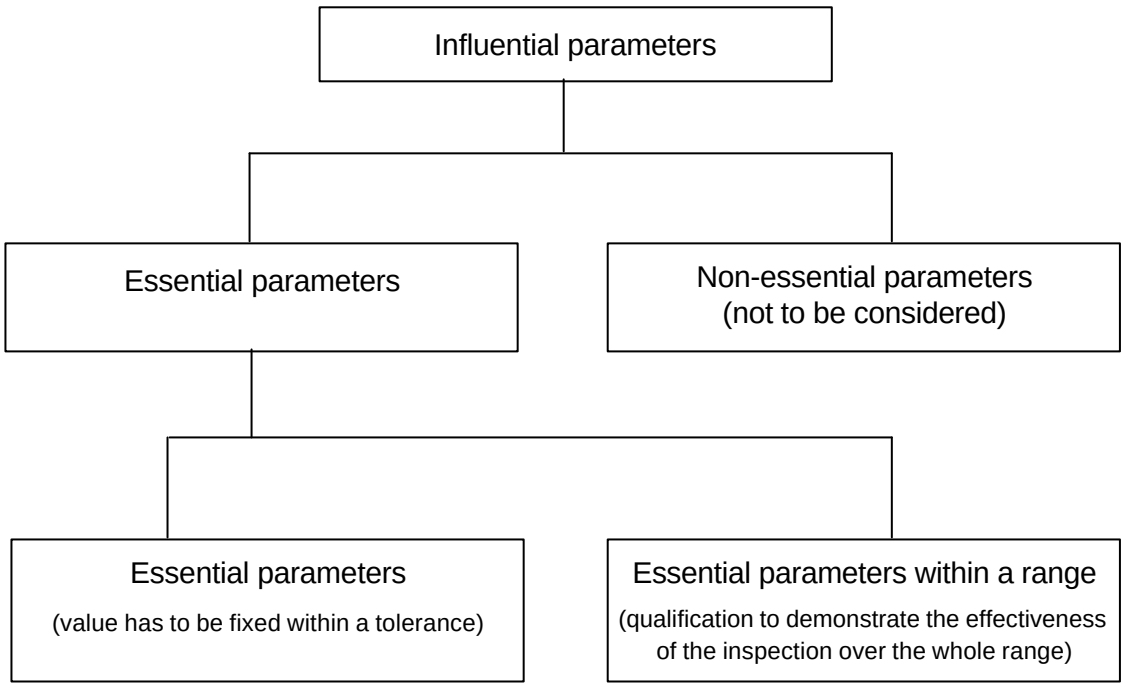

Figure 1: Classification of essential parameters according to the way they will be treated during qualification

4.2.2 ASSESSMENT OF TECHNICAL JUSTIFICATION AGAINST THE CHECKLIST AS GIVEN IN THE QUALIFICATION PROCEDURE

An assessment of the technical justification is given in Table 2, using the checklist given in the qualification procedure.

Table 2: Assessment of the technical justification against checklist as given in the qualification procedure

Checklist	Comments
1. GENERAL	
1.1 Is the document clearly identified as the TJ?	Yes
1.2 Does it make clear which inspection it is supporting?	Yes
1.3 Are the appropriate defects and the tolerances for detection sizing and location identified?	Yes
1.4 Are all the procedures to be qualified identified and considered in the TJ?	Yes
2. ESSENTIAL PARAMETERS	
2.1 Is the complete list of essential parameters given	Yes
2.2 Is a valid justification given why these parameters are considered to be vary within a tolerance/range (references, quality of the information)	Partly, should be completed for an industrial qualification
2.3 Is the tolerance/range indicated between which they can vary	Yes
3. CAPABILITY/INSPECTION PERFORMANCE	
3.1 Does the TJ claim the inspection has the required capability?	Yes, but test piece trials are required to confirm this
3.2 Does the TJ make clear what is understood by the required inspection performance/capability?	Yes, is given in the input information (ISI objectives)
3.3 Does the evidence produced demonstrate that the procedures achieve the required inspection performance	Yes, but test piece trials are required to confirm this
4. DETECTION	
4.1 Does the TJ conclude that the procedures will detect the defects of structural concern?	Yes, to be confirmed through test piece trials
4.2 Is the volume coverage complete?	Yes
4.3 Are all the detection levels and other test parameters clearly and unambiguously stated?	Yes
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?	 Yes No theoretical evidence available, ray tracing would be useful Yes
4.5 Are any uncertainties and limitations identified?	Yes, work to be done to complement information for essential/fixed parameters was identified
4.6 Is any work prepared to reduce the areas of uncertainty, and if so, when are the results likely to be available?	See question 4.5
5 SIZING AND LOCATION	
5.1 Does the TJ conclude that the procedure allows the	Yes

defects to be located and sized within the tolerances (1.3)?	
5.2 Is sufficient evidence presented to confirm the location and sizing claims?	Yes, but to be confirmed through test piece trials
5.3 Does the evidence adequately cover the full range of defects?	Yes
5.4 Has technical judgement been employed?	Yes
5.5 Are any uncertainties and limitations identified?	Yes, see tolerance given for essential/fixed parameters
5.6 Is any work proposed to reduce the errors? When will it be reported?	Yes, will not be done in the framework of this pilot study
6 EQUIPMENT/PROCEDURE	
6.1 Are the standards, including tolerances, for the inspection equipment given?	• No specific standard is used • equipment related fixed parameters (including tolerance) are specified
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)?	• Standard not relevant • Yes, note e.g. that analysis/evaluation scheme is given in inspection procedure for detection
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)?	• Limit case defects have been identified and are present in the test pieces • experimental evidence in the technical justification on similar test pieces is given
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)?	• standard not relevant • yes, but results of test piece trials are needed to complement and confirm these conclusions
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)?	yes, but results of test piece trials are needed to complement and confirm these conclusions

5. MAIN RESULTS OF DESTRUCTIVE EXAMINATION: SIMULATION OF "IGSCC" TYPE DEFECTS

Three different defect manufacturers were used in order to simulate "IGSCC" type defects. Six such defects were introduced in the open test pieces and 4 in the blind test pieces.

Destructive examination learned the following about the characteristics of these defects:

- Four defects in ENIQ test piece 1 and 2, used for the open trials
    - 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 larger through-wall extent
    - Crack tip of defect can be detected in isolation
- two defects in ENIQ test piece 6, used for the open trials:
    - located on the fusion line between weld and base material

    * planar
    * no change in material structure of the weld and base material
- Four defects in ENIQ test piece 9, used for the blind trials
    * Manufacturer used an implantation technique which lead 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

It can be concluded that these IGSCC type defects are not good simulations of real IGSCC.

The 2 defects present in ENIQ test piece 6 are good simulations of fatigue cracks in an unrepaired weld and will be considered as such for the further evaluation of the results.

Within the framework of the ENIQ pilot study the resources were not available in order to do a validation programme of the defects introduced in the test pieces. The experience within the ENIQ pilot study with these “IGSCC” type of defects shows clearly that this is necessary for industrial qualification exercises. It can also be concluded that implantation techniques, which change significantly the austenitic material/weld structure, are not suitable for the introduction of defects in austenitic welds.

It should be stressed that these problems observed for the IGSCC type defects does 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.

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. This kind of “IGSCC” cracks are present in the open and blind test pieces and also in the 1st 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.

6. TEST PIECE TRIALS: FATIGUE DEFECTS

6.1 OPEN TEST PIECE TRIALS

6.1.1 TEST PIECES AND DEFECTS

In total 15 defects, simulating fatigue defects and introduced in 4 different test pieces (ENIQ 3, ENIQ 5, ENIQ 6 and ENIQ 7), were used for the open trials. In Table 3 an overview is given of the essential parameters identified for the components and to which extent it has been possible to cover with the test pieces, used for the open trials and containing fatigue type defects, the variation defined for the essential parameters.

Information on the dimensions of the defects simulating fatigue cracks can be found in Table 4. In total 13 PISC type A defects were used in order to simulate fatigue cracks. Some of these PISC type A defects are combined with manufacturing defects in agreement with the input information. Two defects were introduced by shrinkage buttering. Full details on the defects introduced can be found in the defect catalogue.

Table 3: Overview of extent to which the variation of the essential component parameters was covered with the test pieces used for the open trials and containing fatigue type defects

Essential parameters component	Range	Extent to which test pieces are within variation of essential parameters
Geometry of component	No, double sided access	1 component with elbow
Weld crown configuration	Less than 1.5 mm over a surface of 50 mm x 50 mm	Test pieces within these limits
Weld root	Not ground, Length: 0-30 mm, Protruding part: 4 mm	Test pieces are within these limits
Wall thickness	13.5 - 30 mm	Wall thickness considered: 15 mm 17 mm, 28 mm (2 x)
Pipe diameter	320- 700 mm	Diameters considered: 320 mm (2x), 406 mm (2x)
Counterbore taper angle	< 30 °	Limit case of 30° considered
Position counterbore with respect to weld center line	Between 5 and 180 mm	Case of 180 mm considered in 2 assemblies
Macrostructure base material	Same base material as ISI components	Same base material as ISI components
Macrostructure weld material	Same welding procedure as ISI components	Same welding procedure as ISI components

Table 4: Fatigue type defects present in the test pieces used for the open trials

Defect number	Type of defect	Defect position in weld	through-wall extent (mm)	through-wall extent (% of wall thickness[+])	Length (mm)
3.1	type A + porosities	Weld	12.2 (8.7 for PISC type A)	63 (51 for PISC type A)	48
3.2	type A	Weld +HAZ	8.8	48	55
3.3	type A	Weld +HAZ	8.5	45	56
3.4	type A (skew 15°)	Weld +HAZ	4.0	23	27
3.5	type A (tilt - 30°)	weld fusion line	5.4	30	35
5.1	type A + porosities	Weld	15.7 (9.0 for PISC type A)	92 (57 for PISC type A)	57
5.2	Type A + slag	Weld	5.5 (3.0 for PISC type A)	35 (19 for PISC type A)	32
5.4	type A (tilted + 30°)	fusion line	5.1	30	56
5.6	type A (tilted - 30°)	fusion line	11.6	73	80
6.1	type A (tilted + 30°)	Counterbore	7.4	29	66
6.2	type A (tilted +10°)	Counterbore	14.8	59	81
6.3	Shrinkage buttering (tilted + 22.5°)	Fusion line	14.2	57	23
6.4	Shrinkage buttering (tilted + 22.5°)	Fusion line	11.2	43	23
7.1	narrow slot non-surface-breaking	Weld	3	11	68
7.6	narrow slot non-surface-breaking	Weld	9.1	33	111

[+] in general nominal wall thickness, where full destructive examination was performed measured wall thickness

All the defects considered were surface-breaking except for the 2 defects present in Assembly 7.

An overview of the essential parameters identified for the defects and the extent to which it was possible to cover the variations defined in the technical justification is given in Table 5.

Table 5: Overview of coverage of the variation of the essential defect parameters with the fatigue type defects introduced in the test pieces used for the open trials

Essential parameters of fatigue type defects	Range	Extent to which defects are within tolerance of essential parameters
Defect size	3 mm - 100 % TWE	OK
Defect position along TWE	Non surface-breaking fatigue cracks to be considered	2 such defects considered
Defect position with respect to weld center line	Weld Weld + HAZ Counterbore	Different cases considered
Tilt angle	0-30 °	Worse case is 0° # of defect 0°: 8 # of defects 22.5°: 2 # of defects 30°: 4 # of defects 10°: 1
Skew angle	±10 °	1 defect with skew of 15°
Roughness		Consider limit case of plane defects

In Table 6 an overview is given of the extent of coverage of the different limit cases, identified for the fatigue cracks and achieved with the defects introduced in the test pieces used for the open trials.

Table 6: Different limit cases for the fatigue type defects considered in the test pieces used for the open trials

Different limit cases for fatigue cracks	Requirement	Extent to which requirement was met	
		considering combined fabr. + fatigue defects	not considering combined fabr. + fatigue defects
Detection fatigue cracks: small size	at least 2 defects with size < a_{100}	size < a_{100}: 2 a_{100} < size < a_{qual} : 8 size >= a_{qual}: 5	size < a_{100}: 2 a_{100} < size < a_{qual} : 7 size >= a_{qual}: 3
Detection fatigue defects: embedded fatigue cracks	at least 2 defects	2 defects were considered	
Sizing fatigue defects: Small and large size	at least 2 defects with size < a_{100} at least 2 defects with size > a_{qual}	size < a_{100}: 2 a_{100} < size < a_{qual} : 8 size > a_{qual}: 5	size < a_{100}: 2 a_{100} < size < a_{qual} : 7 size > a_{qual}: 3
Sizing fatigue defects originating from fabrication defects	at least 2 defects	3 defects originating from pre-existing fabrication defects	

6.1.2 CONDUCT OF THE OPEN 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

Prior to the start of the trials the team was given all the information on the test pieces, as described in document ENIQ.PILOT(96)8 including that on the location and dimensions of the defects.

The open trials were continuously invigilated by H. Lohner (JRC Petten) to verify that the inspection sequence as described in the inspection procedure was followed. A log book was kept in which all activities are noted. Here follows an overview of the sequence of events during the open test piece trials:

- 14/1-15/1: ENIQ 2, detection
- 15/1-23/1: no inspections (equipment failed)

- 24/1, 27/1-28/1: ENIQ 3, detection
- 28/1-29/1: ENIQ 5, detection
- 29/1: TOFD on ENIQ 1 and 5: not successful
- 30/1-31/1, 3/2-4/2: pulse echo crack tip and LL technique on ENIQ 1, 2, 5 (not successful)
- 5/2: depth sizing (LL technique), ENIQ 1
- 6/2: depth sizing (LL technique), ENIQ 2
- 7/2: analysis data depth sizing on ENIQ 1 and 2
- 10/2-11/2: depth sizing (LL technique), ENIQ 3
- 11/2- 12/2: depth sizing (LL technique), ENIQ 5
- 13/2: depth sizing (LL technique), ENIQ 1
- 14/2, 17/2-18/2: scanning detection ENIQ 6
- 9/1-13/1: ENIQ 1, detection
- 19/2: TOFD, ENIQ 6 (defect in counterbore region)
- 19/2-20/2: depth sizing (LL technique), ENIQ 6
- 21/2, 24/2: detection + LL technique, ENIQ 7
- data analysis: January-February 1997

It is worthwhile mentioning that there was a failure of an amplifier causing the unavailability of the inspection equipment between 15/1/97 and 23/1/97.

Due to lack of time it had not been possible to optimise completely the depth sizing procedures. Therefore, during one week from 29/1/97 till 4/2/97 laboratory trials were performed in order to optimise the depth sizing procedures. It is clear that this would not have been possible during an industrial qualification exercise.

6.1.3 ASSESSMENT OF THE OBTAINED INSPECTION RESULTS

The obtained inspection results were assessed in 2 ways. First there has been a verification that the inspection team was capable of explaining and justifying the obtained inspection results along 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.

6.1.3.1 JUSTIFICATION/EXPLANATION OF THE INSPECTION RESULTS OBTAINED DURING THE OPEN TRIALS

6.1.3.1.1 AUDIT MEETING OF 28/2/97

On 28/2/97 an audit meeting has been organised in Petten where the following persons were present:

* auditors:
  - M. Hansch PreussenElektra (D)
  - Ph. Benoist CEA (F)
* inspectors:
  - M. Melbi ABB-TRC (S)
  - B. Eriksen JRC Petten (Nl)
* Reference laboratory
  - P. Lemaitre JRC Petten
  - M. Bieth (part-time) JRC Petten
  - S. Crutzen (part-time) JRC Petten

The purpose of this meeting was to assess the results obtained during the open trials. The main emphasis was put on the capability of the inspection team to explain and justify the obtained inspection results along the inspection procedure previously approved by Task Group 2.2 of ENIQ.

a) detection

The following assemblies were discussed in detail as an example in order to assess the open trial results for detection:

* ENIQ Assembly 1, containing 2 simulations of IGSCC defects
* ENIQ Assembly 3, containing 5 simulations of fatigue defects.

The inspection team explained and justified in detail the obtained inspection results along the written inspection procedure. For that purpose the inspection teams showed the relevant A, B- and C-scans and justified how it had reached its decisions to judge the different indications.

Although it was shown clearly that the inspection team had detected all the defects and could justify its decisions it has to be noted that the analysis of the inspection data was not completely done along what is described in the inspection procedure:

- 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

Other remarks, which were made, are as follows:

- colour coding of the presented C-scans should be coherent

- for length sizing it should be specified exactly which transducer is used

It has also to be noted that relatively high scanning sensitivity is used for detection implying that the signals for the defects are in general saturated. However, this was not recognised as a real problem. Note 20 % through-wall extent PISC type A defects were used to determine the scanning sensitivity to be used.

The general opinion of the technical audit group concerning detection was that the inspection procedure for detection was acceptable provided that the clarifications as asked above were introduced in the inspection procedure.

The way the inspection results were explained and analysed along the written inspection procedure is illustrated in more detail in document ENIQ.PILOT(97)19.

b) depth and length sizing

The inspection team presented the sizing results very briefly. The following conclusions can be 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 capable to explain clearly which signals were considered as the crack tip diffracted signals for depth sizing along a well established analysis scheme

As a result of the audit meeting, held on 28/2/97, a revision of the inspection procedure dated 25 April 1997 was issued in order to take into account the remarks which were made at the meeting.

6.1.3.1.2 ASSESSMENT BY THE REFERENCE LABORATORY

A new revision of the inspection procedure was issued on 10 September 1997 as a result of an in-depth analysis done by the Reference Laboratory in order to describe exactly the analysis of the inspection data, which has been performed during the open trials. 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 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 capability to explain the obtained inspection results along 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 exercise a lot of attention has been devoted to a correct description of the analysis scheme to be used during the blind trials.

6.1.3.2 COMPLIANCE WITH ISI OBJECTIVES

Detection

All defects of the fatigue crack type were detected. The detection results could also be explained and justified along the analysis scheme given in the inspection procedure.

False calls

All recorded indications could be attributed to either intended defects or geometrical artefacts such as the weld root, the weld fusion line, etc

Depth sizing

In Table 7 the depth sizing performance for the simulation of the fatigue cracks is given. For 3 of the defects (5.2, 5.4 and 7.1) the inspection team did not detect the crack tip with the LL technique or in pulse-echo. Note that none of these 3 defects was larger than the critical size. Using the 0° probe it was possible to measure the through-wall extent of 2 of these 3 defects. The measured RMS error is 1.9 mm. The maximum undersizing error is 3.3 mm for defect 5.1, which corresponds with 20 % of the wall thickness.

In conclusion the RMS error criterion was easily met for depth sizing of the fatigue type defects. None of the defects was undersized by more than 25 % of the wall thickness. Note that for some of the defects (combined with manufacturing defects) below the critical size it was not possible to detect the crack tip and therefore the inspection team had to rely on the measurements done with the 0° probe.

Table 7: Depth sizing performance achieved for the fatigue crack type defects during the open trials

Defect number	Reference TWE (mm)	measured TWE (mm)		sizing error (mm)	Remarks
		crack tip	0° probe		
3.1	12.2	10.3	11.1	- 1.9	crack tip detected, LL technique (presence of porosity)
3.2	8.8	8.2	-	- 0.6	crack tip detected, LL technique
3.3	8.5	7.4	-	- 1.1	crack tip detected, LL technique
3.4	4.0	3.6	-	- 0.4	crack tip detected, LL technique
3.5	5.4	6.0	-	+ 0.6	crack tip detected, LL technique
5.1	15.7	12.4	-	- 3.3	crack tip detected, LL technique
5.2	5.5	-	4.1	-1.2	no crack tip detected (presence of slag)
5.4	5.1	-	6.7	+1.6	no crack tip detected (presence of porosity)
5.6	11.6	11.4	11.4	-0.2	crack tip detected, LL technique
6.1	7.4	5.9	-	-1.5	TOFD
6.2	14.8	12.7	-	-2.1	TOFD
6.3	14.2	16	-	+1.8	Crack tip detected, LL technique
6.4	11.2	14	-	+2.8	Crack tip detected, LL technique
7.1	3.0	-	-	-3.0	No crack tip detected
7.6	9.1	6.0	-	-3.1	Possible to separate upper and lower crack tip

Length sizing

The length sizing results obtained during the open trials for the fatigue type defects are summarised in Table 8. The corresponding RMS error is 7.4 mm.

Table 8: Length sizing performance for fatigue defects achieved during the open trials

Defect	Reference length (mm)	Measured length (mm)	Sizing error made (mm)
3.1	48	48	0
3.2	56	60	- 4
3.3	56	53	- 3
3.4	27	15	- 12
3.5	35	45	- 10
5.1	59	64	+ 5
5.2	32	36	+ 4
5.4	56	59	+3
5.6	80	77	- 3
6.1	66	66	0
6.2	81	87	+ 6
6.3	23	39	+ 16
6.4	23	30	+ 7
7.1	68	64	- 4
7.6	119	107	-12

6.1.4 CONCLUSIONS OPEN TRIALS FATIGUE TYPE DEFECTS

An important aspect of open trials is to verify that the inspection team is capable to explain in a satisfactory way the results obtained for detection, depth and length sizing of the fatigue type defects. A lot of attention was devoted to this issue by assessing in detail the analysis scheme. The inspection team was capable of explaining and justifying the obtained inspection results using thereby a modified version of the analysis scheme as proposed before the open trials.

The fact that the inspection team has to explain and justify in detail the obtained inspection results in agreement with the written inspection procedure proves to be a good and severe way to qualify an inspection procedure:

- it obliges the inspection team to write a well designed clear and unambiguous inspection procedure
- it provides hard evidence that the results of the inspection team were not obtained by chance
- it allows further to assess the evidence provided in the technical justification which has to be coherent and in agreement with the results obtained during the open trials

It should be recognised that the assessment of the inspection results through open trials asks for highly qualified staff capable of understanding the obtained inspection results.

An overview of the extent to which the ISI objectives were met during the open trials for the fatigue type defects is given in Table 9. It can be concluded that for the fatigue type defects all the ISI objectives were met without any problems.

Task Group 2.2 decided at its meeting held in Petten on 14 May 1997 that for what concerns the fatigue type defects the inspection procedure and equipment could be considered as "qualified" for use during the blind test piece trials.

Table 9: Verification to which extent the ISI objectives were met during open trials

Requirement	fatigue defects
100 % detection rate or defects exceeding 25 % TWE	OK (12 out of 12)
80 % detection rate for defects between 3 mm and 25 % TWE	OK (1 out of 1)
Maximum undersizing permitted is 25 % TWE or 5 mm	OK
RMS error for depth sizing < 3 mm	OK RMS = 1.9 mm
RMS error for length sizing < 20 mm	OK RMS = 7.4 mm
false calls	OK

6.2 BLIND TEST PIECE TRIALS

6.2.1 TEST PIECES AND DEFECTS

In total 12 defects, simulating fatigue defects, and introduced in 3 different assemblies (ENIQ 4, ENIQ 7 and ENIQ 8), were used for the blind trials. In Table 10 an overview is given of the essential component parameters and the extent to which it has been possible to cover the variation of the these essential parameters with the test pieces used for the blind trials and containing fatigue type defects.

Table 10: Coverage of variation of essential component parameters with test pieces used for the blind trials and containing fatigue type defects

essential parameters component	Range	Extent to which test pieces are within tolerance essential parameters
geometry of component	No, double sided access	OK
weld crown configuration	Less than 1.5 mm over a surface of 50 mm x 50 mm	Test pieces within these limits
weld root	Not ground; Length: 0-30 mm Protruding part: 4 mm	Test pieces are within these limits
wall thickness	13.5 - 30 mm	Wall thickness considered: 17 mm 25.4 mm 28 mm
pipe diameter	320- 700 mm	Diameters considered: • 320 mm (2x) • 406 mm (1x)
Counterbore taper angle	< 30 °	limit case of 30° considered
Position counterbore with respect to weld center line	Between 5 and 180 mm	case of 150 and 180 mm, respectively, considered in 2 assemblies
Macrostructure base material	- Typically wrought stainless steel - Same material as for real component was used	- Typically wrought stainless steel - Same material as for real component was used
Macrostructure weld material	Same welding procedure as the one for the 1st set of ISI components was used	Same welding procedure as the one for the 1st set of ISI components was used

Information on the dimensions of the defects simulating fatigue cracks can be found in Table 11. PISC type A defects were used in order to simulate fatigue cracks.

All the defects considered were surface-breaking except for defects 4.2, 7.2 and 7.4.
An overview of the essential parameters identified for the defects and the extent to which it was possible to cover the variations of these parameters with the fatigue type defects introduced in the test pieces used for the blind trials is given in Table 12.

Table 11: Fatigue type defects, present in the assemblies for the blind trials

Defect number	type of defect	Intended position in weld	through-wall extent (% of wall thickness)	Through-wall extent (mm)	length (mm)
4.1	type A tilted 30º	Weld	28	7.8	48
4.3	type A tilted 30º	Counterbore	27	7.2	55
4.4	type A	Weld	27	6.5	43
4.5	type A Tilted 30º	Weld	53	12.8	91
7.2	Narrow slot Tilted 22.5º	Weld	26	8.2	111
7.3	type A tilted 30º	Counterbore	16	4.4	33
7.4	Narrow slot	HAZ	38	10.7	110
7.5	type A skewed 10º	Counterbore	31	8.7	70
8.1	type A tilted 30º	Weld fusion line	48	9.5	61
8.2	Type A Tilted 10º	HAZ + weld	44	8.0	55
8.3	Type A	Weld	62	12.4	75
8.4	Type A Tilted 10 º	HAZ +Weld	63	11.5	71

Table 12: Overview of coverage of the variation of the essential defect parameters with the fatigue type defects introduced in the test pieces used for the blind trials

Essential parameters fatigue cracks	Range	extent to which test pieces are within tolerance of essential parameters
defect size	3 mm - 100 % TWE	OK
defect position along TWE	non surface-breaking fatigue cracks to be considered	2 such defects considered
defect position with respect to weld center line	Weld weld + HAZ (weld fusion line) counterbore	different cases considered
tilt angle	0-30 °	worse case is 0° # of defect 0°: 4 # of defects 10°: 2 # of defects 22.5º: 1 # of defects 30º: 5
skew angle	±10 °	1 defect with skew of 10°
roughness		consider limit case of plane defects

In Table 13 an overview is given of the extent of coverage of the different limit cases, identified for the fatigue cracks in the technical justification, as achieved with the fatigue type defects introduced in the blind test pieces. Note that in the qualification procedure it is said that the limit cases should mainly be present in the test pieces to be used for the open trials whereas the test pieces to be used for the blind trials should be focused more on “average” defect cases.

Table 13: Limit cases for the fatigue type defects, which were considered in the test pieces for the blind trials

different limit cases for fatigue cracks	Requirements	Extent to which requirement was met
Detection fatigue cracks: small size	at least 2 defects with size < a_{100}	size < a_{100}: 1 a_{100} < size < a_{qual} : 8 size > a_{qual}: 3
detection fatigue defects: embedded fatigue cracks	at least 2 defects	2 embedded defects
Sizing fatigue defects: small and large size	at least 2 defects with size < a_{100} at least 2 defects with size > a_{qual}	size < a_{100}: 1 a_{100} < size < a_{qual} : 8 size > a_{qual}: 3
Sizing fatigue defects originating from fabrication defects	at least 2 defects	No fatigue defects originating from fabrication defects present

6.2.2 CONDUCT OF THE BLIND TEST PIECE TRIALS

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

Prior to the start of the trials the team was given all the information on the test pieces as described in document ENIQ.PILOT(96)8, excluding that on the number, location and dimensions of the defects introduced.

The blind test trials were continuously invigilated by H. Lohner (JRC Petten) to verify that the inspection sequence as described in the inspection procedure was followed. A log book was kept in which all activities are noted. Here follows an overview of the sequence of events during the blind test piece trials:

- 25/2-26/2; ENIQ 7, detection + sizing pulse-echo
- 27-28/2: ENIQ 4, detection
- 4/3: ENIQ 4, detection
- 5/3: ENIQ 4, depth sizing TOFD + LL technique
- 6/3: ENIQ 4, depth sizing LL technique

- 7/3: ENIQ 8, detection
- 10-14/3: no inspection due to seminar on inspection qualification
- 17/3: ENIQ 8, detection + depth sizing LL technique
- 18/3: ENIQ 8, depth sizing LL technique
- 18-19/3: ENIQ 9, detection
- 19/3: ENIQ 9, detection
- 20/3: ENIQ 9, detection + depth sizing LL technique
- 21/3: ENIQ 9: depth sizing LL technique
- analysis of the inspection results: October-November 1997

6.2.3 ASSESSMENT OF THE OBTAINED INSPECTION RESULTS

The obtained inspection results were assessed in 2 ways. First there has been a verification that the inspection team was capable of explaining and justifying the obtained inspection results along the analysis/evaluation scheme given in the inspection procedure. Secondly there was an assessment to verify that the ISI objectives are met.

6.2.3.1 JUSTIFICATION/EXPLANATION OF THE INSPECTION RESULTS OBTAINED DURING THE BLIND TRIALS

No specific problems were encountered by the inspection team in order to follow the analysis/evaluation scheme of the inspection procedure for the blind trials. A short summary of the results obtained in this respect by the inspection team is given in document ENIQ.PILOT(97)19.

6.2.3.2 COMPLIANCE WITH ISI OBJECTIVES

Detection

All defects of the fatigue type were detected.

False calls

No false calls were made. All recorded indications could be attributed to either intended defects or geometrical artefacts (such as weld root, weld fusion line, etc.). Note further that the inspection team detected also a number of small unintended defects in ENIQ 7 and correctly classified them as such. X-ray examination of the test pieces confirmed indeed the presence of a relatively large number of small unintended defects in ENIQ 7.

Depth sizing

In Table 14 the depth sizing performance for the simulation of the fatigue cracks, achieved during the blind trials, is given.

None of the defects was undersized by more than 25 % of the wall thickness. The RMS error calculated for the fatigue type defects is 1.6 mm. In conclusion for the simulations of the fatigue type defects the RMS error criterion was easily met.

Table 14: Depth sizing performance achieved for the fatigue crack type defects during the blind trials

Defect number	reference TWE (mm)	Measured TWE (mm)	Sizing error (mm)	Remarks
4.1	7.8	16		• Unintended defects were detected by inspection team, not verified by destructive examination • Defect will not be considered for assessment of inspection results
4.3	7.2	7.5	+ 0.3	crack tip detected, TOFD
4.4	6.5	6.0	- 0.5	crack tip detected, LL technique
4.5	12.8	11.5	- 1.3	crack tip detected, LL technique
7.2	8.2	11.0	+ 2.8	crack tip detected, pulse-echo
7.3	4.4	3.5	- 0.9	crack tip detected, pulse-echo
7.4	10.7	10	- 0.7	crack tip detected, pulse-echo
7.5	8.7	7.5	- 1.2	crack tip detected, pulse-echo
8.1	9.5	8.2	- 1.3	crack tip detected, LL technique
8.2	8.0	6.2	- 1.8	crack tip detected, LL technique
8.3	12.4	9.9	- 2.5	crack tip detected, LL technique
8.4	11.5	9.8	- 1.7	crack tip detected, LL technique

length sizing

The length sizing results obtained during the blind trials for the fatigue type defects are summarised in Table 15. The corresponding RMS error measured is 6.0 mm.

Table 15: Length sizing performance for fatigue defects achieved during the blind trials

Defect	Reference length (mm)	Measured length (mm)	sizing error made (mm)
4.1	48	38	- 10
4.3	55	62	+ 7
4.4	43	45	+ 2
4.5	91	96	+ 5
7.2	111	98	- 13
7.3	33	37	+ 4
7.4	110	107	-3
7.5	70	70	0
8.1	55	57	+ 2
8.2	55	55	+ 0
8.3	75	70	-5
8.4	71	77	+ 6

6.2.4 CONCLUSIONS BLIND TRIALS

The assessment of the inspection results obtained during the blind trials shows that the ISI objectives for detection, false calls, depth and length sizing were met for the fatigue crack type defects.

In Table 16 an overview is given to which extent the ISI objectives were met during the blind trials.

Table 16: Verification of the extent to which the ISI objectives were met during the blind trials

Requirement	fatigue defects
100 % detection rate or defects exceeding 25 % TWE	OK (11 out of 11)
80 % detection rate for defects between 3 mm and 25 % TWE	OK (1 out of 1)
Maximum undersizing permitted is 25 % TWE or 5 mm	OK
RMS error for depth sizing < 3 mm	OK RMS = 1.6 mm
RMS error for length sizing < 20 mm	OK RMS = 6.0 mm
false calls	OK

All ISI objectives are met except. Therefore the Steering Committee of ENIQ decided at its meeting of 2 and 3 December 1997 in Petten gave the formal approval to go ahead with the ISI trials for fatigue type defects. The inspection procedure, equipment and personnel are considered to be “qualified” for use during the ISI trials.

6.3. COMPARISON BETWEEN OPEN AND BLIND TRIAL RESULTS

In Table 17 a comparison is made between the open and blind trials and the inspection results obtained. From this table it can be concluded that the inspection performance achieved during the blind trials for detection and false calls is the same as that achieved during the open trials. For the fatigue type defects the depth and length sizing performance, achieved during the blind trials, is even slightly better than that achieved during the open trials.

Table 17: Comparison between the inspection results obtained during the open trials and those obtained during the blind trials

	Open trials	Blind trials
Number of defects considered	15	12
Detection	All defects detected	All defects detected
False calls	No false calls made	No false calls made
Depth sizing: undersizing by more than 25 % of the wall thickness	None	none
Depth sizing: RMS error (mm)	1.9	1.6
Length sizing: RMS error (mm)	7.4	6.0
Capability of explaining inspection results	OK, but analysis scheme has to be adapted on some points	OK

7. TEST PIECE TRIALS: “IGSCC” TYPE DEFECTS

In this section the obtained inspection results for the “IGSCC” type defects obtained during the qualification trials are given for information. As already discussed before these defects were intended to simulate IGSCC. Destructive examination has, however, revealed that this was not the case.

7.1 OPEN TEST PIECE TRIALS

7.1.1 TEST PIECES CONTAINING "IGSCC" TYPE DEFECTS

In total 4 defects, simulating "IGSCC" type defects, and introduced in 2 different assemblies (ENIQ 1, ENIQ 2) were used for the open trials.

In Table 18 an overview is given of the essential parameters identified for the components and to which extent it has been possible to cover the variation of these essential component parameters with the test pieces used for the open trials.

Table 18: Overview of extent to which variation of essential component parameters was covered with the test pieces used for the open trials

Essential parameters component	Range	Extent to which test pieces are within tolerance essential parameters
Geometry of component	no, double sided access	OK
weld crown configuration	Less than 1.5 mm over a surface of 50 mm x 50 mm	test pieces within these limits
weld root	not ground; length: 0-30 mm protruding part: 4 mm	test pieces are within these limits
wall thickness	13.5 - 30 mm	Wall thickness considered: 25 mm (2x)
pipe diameter	320- 700 mm	Diameters considered: 320 mm (2x)
Counterbore taper angle	< 30 °	not relevant
Position counterbore with respect to weld center line	Between 5 and 180 mm	Case of 6 mm considered in 2 assemblies
Macrostructure base material	- Typically wrought stainless steel - Same material as for real component was used	- Typically wrought stainless steel - Same material as for real component was used
Macrostructure weld material	Same welding procedure and weld repair method as the one for the 1st set of ISI components was used	Same welding procedure and weld repair method as the one for the 1st set of ISI components was used

Information on the dimensions of these defects can be found in Table 19.

Table 19: Defects used to simulate fatigue defects in repair welds, present in the test pieces used for the open trials

Defect number*	defect type	Position	through-wall extent (% of wall thickness)	Through-wall extent (mm)	length (mm)
1.1	“IGSCC”	Weld	44	11	25
1.2	“IGSCC”	Weld	24	6	20
2.1	“IGSCC”	Weld	79	19.7	34
2.2	“IGSCC”	Weld	61	15.4	34

* the first number refers to the number of the ENIQ assembly; the second number refers to the number of the defect in the assembly

An overview of the essential defects parameters and the extent to which it was possible to cover the variation of these essential parameters as defined in the technical justification with the defects present in the test pieces used for the open trials is given in Table 20.

Table 20: Overview of extent to which variation of essential defect parameters was covered with the “IGSCC” type defects introduced in the test pieces used for the open trials

essential parameters defects	Range	extent to which test pieces are within tolerance defined for the essential parameters
defect size	3 mm – 100 % TWE	OK
defect position along TWE	not relevant for “IGSCC” as they are all surface-breaking	-
defect position with respect to weld center line	HAZ	OK
tilt angle	0-30 °	worst case is 0° all defects are at 0°
skew angle	±10 °	all defect are at 0°
Roughness	How to quantify? Consider limit case of plane defects	
branching of “IGSCC”	Similar to what is present in the first set of ISI assemblies	Similar to what is present in the first set of ISI assemblies

In Table 21 the different limit cases are given for the defects, which were identified as a result of the technical justification.

Table 21: Different limit cases for the “IGSCC” type defects, considered in the open test piece trials

different limit cases for “IGSCC”	Requirement	extent to which requirement was met
detection “IGSCC”: small size	At least 2 defects with size < a_{100}	size < a_{100}: 1 a_{100} < size < a_{qual} : 1 size > a_{qual}: 2
detection “IGSCC”: • Tilt of 0° • Skew ± 10°	At least 2 defects of each case	tilt: 4 at 0° skew: all 0°
sizing “IGSCC”: small and large size	At least 2 defects with size < a_{100} At least 2 defects with size > a_{qual}	size < a_{100}: 1 a_{100} < size < a_{qual} : 1 size > a_{qual}: 2

7.1.2 CONDUCT OF OPEN TEST PIECE TRIALS

The open trials were conducted at the same time as the open trials for the fatigue type defects. More details can be found in section 6.2.

7.1.3 ASSESSMENT OF THE OBTAINED INSPECTION RESULTS

7.1.3.1 JUSTIFICATION/EXPLANATION OF THE INSPECTION RESULTS OBTAINED DURING THE OPEN TRIALS

The assessment was done in a similar way as for the fatigue type defects.

7.1.3.2 COMPLIANCE WITH ISI OBJECTIVES

Detection

All defects were detected. Note that there were no signals visible in the ultrasonic images showing the difference in macrostructure between the material around the defect and the rest of the weld.

False calls

No false calls were made

Depth sizing

In Table 22 a summary is made for the depth sizing performance achieved for the “IGSCC” type defects.

Table 22: Depth sizing performance for the “IGSCC” type defects, achieved during the open trials

Defect Number	Reference TWE	Measured TWE (mm)	sizing error (mm)	Remarks (declarations of the team)
1.1	11	9.3	- 1.7	Crack tip detected, LL technique
1.2	6	12.7	+ 6.7	Crack tip detected, LL technique
2.1	19.7	17.6	- 2.1	Crack tip detected, LL technique
2.2	15.4	10.4	- 5.0	Crack tip detected, LL technique

The large oversizing error made for defect 1.2 is difficult to explain. The largest undersizing made was 5.0 mm (for defect 2.2), corresponding with 20 % of the wall thickness. This may be due to the fact that the deepest point of the fork of the branched crack was detected. The corresponding RMS error is 4.4 mm.

Length sizing

The length sizing results obtained during the open trials for the “IGSCC” type defects are summarised in Table 23. The corresponding RMS error is 19.3 mm.

Table 23: Length sizing performance for “IGSCC” achieved during the open trials

Defect	Reference length (mm)	Measured length (mm)	Sizing error made (mm)
1.1	25	43	+ 18
1.2	20	48	+ 28
2.1	34	50	+ 16
2.2	34	45	+ 11

7.1.4 CONCLUSIONS OPEN TRIALS "IGSCC" TYPE DEFECTS

An overview of the extent to which the ISI objectives were met formally during the open trials is given in Table 24.

Table 24: Verification to which extent the ISI objectives were met during open trials for "IGSCC" type defects

Requirement	"IGSCC" type defects
100 % detection rate or defects exceeding 25 % TWE	OK, 3 out of 3
80 % detection rate for defects between 3 mm and 25 % TWE	OK, 1 out of 1
Maximum undersizing permitted is 25 % TWE or 5 mm	OK
RMS error for depth sizing < 3 mm	Not met, RMS = 4.6 mm
RMS error for length sizing < 20 mm	OK, RMS = 19.6 mm
False calls	OK

7.2 BLIND TEST PIECE TRIALS

7.2.1 TEST PIECE CONTAINING "IGSCC" TYPE DEFECTS

In total 4 defects, simulating "IGSCC" defects, and introduced in 1 single test piece (ENIQ 9) were used for the blind trials. It should be stressed that the defect manufacturer used for this test piece was different from the one which was used for the test pieces used during the open trials.

In Table 25 an overview is given of the essential parameters identified for the components and the extent to which it has been possible to cover the variation of the component essential parameters with the test piece used for the blind trials.

Table 25: Coverage of variation of essential component parameters with the test piece used for the blind trials and containing “IGSCC” type defects

Essential parameters of the component	Range	Extent to which test pieces are within tolerance of essential parameters
Geometry of component	No, double sided access	OK
weld crown configuration	Less than 1.5 mm over a surface of 50 mm x 50 mm	Ground
weld root	Not ground; Length: 0-30 mm Protruding part: 4 mm	Ground
wall thickness	13.5 - 30 mm	Wall thickness considered: 25 mm
Pipe diameter	320- 700 mm	Diameter considered: 320 mm
Counterbore taper angle	< 30 °	No counterbore present
Position counterbore with respect to weld center line	Between 5 and 180 mm	No counterbore present
Macrostructure base material	Similar to the ISI components	Similar to ISI components
Macrostructure weld material	Similar to repair weld in ISI components	Similar to repair weld in ISI components

Information on the dimensions of the defects introduced in test piece 9 can be found in Table 26.

Table 26: Defects used to simulate “IGSCC” type defects, which were present in the test piece used for the blind trials

Defect number*	defect type	Position	through-wall extent (% of wall thickness)	Through-wall extent (mm)	Length (mm)
9.1	“IGSCC”	Weld	43	11.0	53
9.2	“IGSCC”	Weld	76	19.3	54
9.3	“IGSCC”	Weld	37	9.5	51
9.4	“IGSCC”	Weld	17	4.4	47

An overview of the essential parameters identified for the defects and the extent to which it was possible to cover the variations defined in the technical justification with the IGSCC type defects introduced in the test piece used for the blind trials is given in Table 27.

Table 27: Extent to which it was possible to cover the variation of the essential defect parameters with the “IGSCC” type defects, introduced in the test piece used for the blind trials

Essential parameters defects	Range	Extent to which test pieces are within tolerance defined for the essential parameters
defect size	3 mm – 100 % TWE	OK
defect position along TWE	Not relevant for IGSCC as they are all surface-breaking	-
defect position with respect to weld center line	HAZ	OK
tilt angle		3 defects at 0° 1 defect at 12.5°
skew angle	±10 °	2 defects at 0° 2 defects at 10°
Roughness	How to quantify? Consider limit case of plane defects	
Branching of IGSCC	DE	DE

The different “IGSCC” defect limit cases, which were considered for the blind trials, are summarised in Table 28.

Table 28: Different limit cases for “IGSCC”, considered in the blind trials

different limit cases for “IGSCC”	Requirement	extent to which requirement was met
Detection “IGSCC”: small size	at least 2 defects with size < a_{100}	size < a_{100}: 1 a_{100} < size < a_{qual} : 2 size > a_{qual}: 1
detection “IGSCC”: • Tilt of 0° • Skew ± 10°	at least 2 defects of each case	tilt: 3 at 0° and 1 at 22.5° skew: 2 at 0° and 2 at 10°
sizing “IGSCC”: small and large size	at least 2 defects with size < a_{100} at least 2 defects with size > a_{qual}	Size < a_{100}: 1 a_{100} < size < a_{qual} : 2 size > a_{qual}: 1

7.2.2 CONDUCT OF BLIND TEST PIECE TRIALS FOR "IGSCC" TYPE DEFECTS

The blind trials for the fatigue and "IGSCC" type defects were conducted at the same time. More details can be found in section 6.2.2

7.3 ASSESSMENT OF THE OBTAINED INSPECTION RESULTS

The obtained inspection results were assessed in 2 ways. First there has been a verification that the inspection team was capable of explaining and justifying the obtained inspection results along the analysis/evaluation scheme given in the inspection procedure. Secondly there was an assessment to verify that the ISI objectives are met.

7.3.1 JUSTIFICATION/EXPLANATION OF THE INSPECTION RESULTS OBTAINED DURING THE BLIND TRIALS

No specific problems were encountered by the inspection team in order to follow the analysis/evaluation scheme of the inspection procedure for the blind trials. A short summary of the results obtained in this respect by the inspection team is given in document ENIQ.PILOT(97)19.

7.3.2 COMPLIANCE WITH ISI OBJECTIVES

Detection

All defects of the "IGSCC" type were detected. There were indeed clear signals corresponding with the defects.
Note that in he ultrasonic images there is also evidence on the presence of the implants

False calls

No false calls were made.

Depth sizing

In Table 29 a summary is made for the depth sizing performance achieved during the blind trials for the "IGSCC" type defects.

Table 29: Depth sizing performance for “IGSCC” type defects, achieved during the blind trials

Defect Number	Reference TWE (mm) obtained by DE	TWE implant (mm)	TWE (mm) measured by ultrasonics	Difference between UT TWE and reference TWE obtained by DE (mm)	Difference between UT TWE and implant TWE (mm)
9.1	11.0	14.8	16.3	+ 5.3	+1.5
9.2	19.3	21.8	20.3	+ 1.0	-1.5
9.3	9.5	15.0	15.0	+ 5.5	0.0
9.4	4.4	8.0	9.5	+ 5.1	-1.5

None of the “IGSCC” defects was undersized by more than 25 % of the wall thickness.
All defects were considerably oversized, leading to an RMS error of 4.6 mm, which is higher than the 3.0 mm as given in the ISI objectives. In Table 29 the difference between the ultrasonically measured through-wall extent and the implant is also given. The measured values for this difference are rather small, which suggest strongly that the inspection team did not measure the through-wall extent of the defects but that of the implant. The inspection procedure foresees indeed that the signals corresponding with the largest depth are taken as the reference for determining the through-wall extent of the defects.

A more detailed analysis was done by the inspection team, after the blind practical trials, in order to verify whether any signals could be detected which may have originated from the crack tip of these implanted defects. Relatively clear signals were observed which give rise to values for the through-wall extent as given in Table 30.

Table 30: Through-wall extent, determined using signals, which are most probably due to the crack tip of the defects

Defect number	Reference TWE obtained by DE (mm)	TWE deduced from (crack tip) signal below signal corresponding with implant
9.1	11.0	10.9
9.2	19.3	Good agreement
9.3	9.5	12.9
9.4	4.4	4.1

As can be deduced from Table 30 there is a relatively good agreement between these new values and the reference through-wall extent of these defects. This shows that there is

information in the inspection data which could lead to the correct depth sizing of these implanted defects. This is important because if one knows beforehand that one has to deal with implanted defects simulating "IGSCC" cracks this knowledge can be used to differentiate between signals originating from the implant and the defect. The RMS error corresponding with these new measurements is 1.8 mm.

Length sizing

The length sizing results obtained during the blind trials for the "IGSCC" type defects are summarised in Table 31.

Table 31: Length sizing performance for "IGSCC" type defects achieved during the blind trials

defect	Reference defect length measured by DE (mm)	Length measured by ultrasonics (mm)	Length of implant (mm)	Difference between UT length and reference length measured by DE (mm)	Difference between UT length and implant length (mm)
9.1	53	62	70	+ 9	-8
9.2	54	67	65	+13	-2
9.3	51	62	88	+11	-16
9.4	47	60	73	+13	-13

The RMS error for length sizing of the "IGSCC" type defects is 11.6 mm. In 3 out of the 4 cases the UT measured length is somewhere midway in between the real defect length and implant length.

7.3.3 CONCLUSIONS BLIND TRIALS "IGSCC" TYPE DEFECTS

During the blind trials for the "IGSCC" type defects clear signals corresponding with the defects were detected. Note that also the implant was visible in the ultrasonic images. No false calls were made.

For depth sizing of the "IGSCC" type defects the ISI objectives were not met (RMS error of 4.6 mm) due to the fact that most probably the through-wall extent of the implant was measured. More detailed analysis showed below the signal corresponding with the implant there were other signals which are originating from the crack itself. When taking the depths corresponding with these signals the RMS error is 1.8 mm. None of the "IGSCC" type defects was undersized by more than 25 % of the wall thickness.

The RMS criterion for length sizing was easily met.

In Table 32 an overview is given to which extent the ISI objectives were met during the blind trials.

Table 32: Verification of the extent to which the ISI objectives were met during the blind trials

Requirement	"IGSCC"
100 % detection rate or defects exceeding 25 % TWE	OK (3 out of 3)
80 % detection rate for defects between 3 mm and 25 % TWE	OK (1 out of 1)
Maximum undersizing permitted is 25 % TWE or 5 mm	OK
RMS error for depth sizing < 3 mm	No RMS = 4.6 mm (implant) RMS = 1.8 mm (defects)
RMS error for length sizing < 20 mm	OK RMS = 11.6 mm
false calls	OK

7.4 COMPARISON BETWEEN OPEN AND BLIND TRIAL RESULTS FOR "IGSCC" TYPE DEFECTS

In Table 33 a comparison is made between the open and blind trials and the inspection results obtained. From this table it can be concluded that the inspection performance achieved during the blind trials for detection and false calls is the same as that achieved during the open trials. For the fatigue type defects the depth and length sizing performance, achieved during the blind trials, is even slightly better than that achieved during the open trials.

For what concerns the depth sizing performance of the IGSCC type defects the provisional conclusion is that the performance achieved during the open trials is slightly better than that achieved during the blind trials. However, the results of destructive examination are required in order to confirm this. The main purpose of the destructive examination is to verify the exact through-wall extent of the IGSCC type defects and the possible way the fabrication methods may have influenced the ultrasonic measurements.

Table 33: Comparison between the inspection results obtained during the open trials and those obtained during the blind trials

	Open trials	Blind trials
Number of defects considered	4	4
Detection	All defects detected	All defects detected
False calls	No false calls made	No false calls made
Depth sizing: undersizing by more than 25 % of the wall thickness	OK	OK
Depth sizing: RMS error (mm)	4.4	4.6 (implant) 1.8 (defect)
Length sizing: RMS error (mm)	19.3	11.6
Capability of explaining inspection results	Analysis scheme to be adapted to take into account presence of repairs, especially for depth sizing	Analysis scheme to be adapted to take into account presence of repairs, especially for depth sizing

Whereas the detection and false call performance are similar for the open and blind trials this is not the case for the sizing performance. The results of destructive examination have shown that the characteristics of the “IGSCC” type defects for the open and blind trials are different due to the different manufacturing methods used. This probably explains the difference observed in depth and length sizing results between the open and blind trials.

8. FABRICATION DEFECTS

In the test pieces considered for the open trials, there were also 3 fabrication defects present. Fabrication defects as such were not part of the defect specification for this pilot study.

However, for the sake of completeness the inspection results obtained on these fabrication defects are also reported here. All 3 fabrication defects were detected. In Table 34 and 35 the results obtained for depth and length sizing, respectively, are reported. It is worthwhile mentioning that the inspection team correctly characterised these manufacturing defects as non-surface-breaking.

Table 34: Depth sizing performance for fabrication defects

Defect number	Reference TWE (mm)	measured TWE (mm)	Remarks
5.3 (LOF)	4	-	• characterised as a non-surface-breaking defect • location given in depth with 0° probe • not sized in depth
5.5 (LOF)	5.6	-	• characterised as non-surface-breaking defect • location given in depth with 0° probe • not sized in depth
5.7 (slag)	2.6	-	• characterised as non-surface-breaking defect • location given in depth with 0° probe • not sized in depth

Table 35: Length sizing performance for fabrication defects

Defect number	Reference length obtained by DE(mm)	Measured UT length (mm)	Error (mm)
5.3 (LOF)	19	26	+ 7
5.5 (LOF)	28	23	- 5
5.7 (slag)	11	15	+ 4

The RMS error for length sizing of the fabrication defects is 5.5 mm.

9. CONCLUSIONS

In this report a detailed overview is given of how the inspection results were assessed during the ENIQ pilot study using technical justification, open and blind test piece trials.

The most important conclusion from the assessment of the qualification results obtained during the first ENIQ pilot study is that the inspection results obtained during the open and blind trials are consistent with each other. Problems observed during the open trials such as the depth sizing of the "IGSCC" type defects occurred also during the blind trials. The ISI requirements which were met during the open trials were also met during the blind trials. This shows that that it is feasible to apply the European methodology in a satisfactory way in order to verify that an inspection system meets its stated objectives.

The work done for the assessment of the ENIQ pilot study results has also shown the need to provide more detailed guidelines on a number of issues such as:

- influential/essential parameters
- technical justification
- the contents of the qualification dossier and the importance to correctly define the required input information
- how to conduct test piece trials (especially open ones)

This was achieved through the publication of the following ENIQ recommended practices:

- ENIQ Recommended Practice 1: Influential/essential parameters, Issue 1, ENIQ Report 6, EUR 18101 EN, published by the European Commission, Brussels-Luxembourg, 1998.
- ENIQ Recommended Practice 2: Recommended contents for a technical justification, Issue 1, ENIQ report 4, EUR 18099 EN, published by the European Commission, Brussels-Luxembourg, 1998
- ENIQ Recommended Practice 3: Strategy document for technical justification, Issue 1, ENIQ Report 5, EUR 18100 EN, published by the European Commission, Brussels-Luxembourg, 1998.
- ENIQ Recommended Practice 4: recommended contents for the qualification dossier, ENIQ Report 13, EUR 18685 EN, published by the European Commission, Brussels-Luxembourg, 1999.
- ENIQ Recommended Practice 5: Guidelines for the design of test pieces and the conduct of open and blind test piece trials, ENIQ Report 14, EUR 18686 EN, published by the European Commission, Brussels-Luxembourg, 1999.
- ENIQ Recommended Practice 6: The use of modelling in inspection qualification, ENIQ Report 15, EUR 19017 EN, published by the European Commission, Brussels-Luxembourg, 1999.

The following recommended practices are as of now (December 1999) still under discussion:

- ENIQ Recommended Practice 7: General requirements for a body operating qualification of non-destructive tests
- ENIQ Recommended Practice 8: Definition of qualification objectives from ISI objectives

More work, however, is still needed on how technical justification can be used to reduce the number of test piece trials. It was not possible to highlight this aspect during the first pilot study due to the fact that an austenitic component had been chosen. That is why the Steering Committee of ENIQ has decided to launch a second pilot study on a ferritic component in order to verify to which extent, for example, modelling or parametric studies can be used for that purpose.

More work is also needed on manufacturing of IGSCC defects. This pilot study has identified the problems that may occur when introducing realistic defects, simulating IGSCC, in austenitic structures, due to the difference in macrostructure between the material around the defects and the original material. Therefore the use of artificial defects, which simulate the NDT behaviour of the real defects, is recommended. For example, in case of ultrasonics, PISC type A defects manufactured by electro-erosion, have a very sharp notch tip and can under certain conditions simulate the crack tip behaviour of planar smooth defects, typical for fatigue cracks not under compression. The main advantages of the use of artificial defects with respect to so-called real defects, obtained by for example corrosion, thermal or mechanical fatigue, are the following:

- Characteristics of the defects (position and dimensions) are exactly known
- Manufacturing process is simpler, more cost-efficient and less time-consuming
- The material surrounding the defect is left in the original state.

However, this requires more research work in order to better understand the relationship between the NDT behaviour of real and that of synthetic defects, simulating real defects.

APPENDIX 1A

DETAILED REMARKS MADE DURING THE TECHNICAL ASSESSMENT MEETING OF 26 NOVEMBER 1996 IN SCHIPHOL ON THE ENIQ PILOT STUDY INSPECTION PROCEDURE (VERSION OF 18 NOVEMBER 1996)

DETAILED REMARKS MADE DURING THE TECHNICAL ASSESSMENT MEETING OF 26 NOVEMBER 1996 IN SCHIPHOL ON THE ENIQ PILOT STUDY INSPECTION PROCEDURE (VERSION OF 18 NOVEMBER 1996)

Page 4

Under point 2: scope of the inspection procedure

- just mention in general for which the inspection procedure will be used
- provide drawings of the components
- mention tilt/skew angle
- mention defect sizes

The Reference Laboratory remarked that all this information could be found in the input information.

Page 5

- Is the European methodology really an applicable document

Page 6: surface conditions

- flush has a clear definition , it would be better to replace flush by “smooth transition”
- operator should report on position of the weld centre line
- make a separate chapter on co-ordinate system

Page 6: inspection personnel

- formal training and in-service inspection experience is too general and should be more specific and should be written is such a way that it can be checked formally by qualification body; certificates on training should be mentioned; full documentation is not necessary for the pilot study but principle should be mentioned

Page 9

- all items mentioned under 7.1 should not be mentioned; possible settings of equipment should be given in reference document
- description of equipment should be referenced

Page 10: probed to be used

- descriptive part should be removed

Page 11:

- contouring, shoe characteristics should be described
- focal distance not completely adapted to thinner wall thicknesses

- mention probe housing and crystal dimensions of AMDATA probes
- replacement should be discussed in a reference document; it is not possible to treat this issue in full detail in the framework of the pilot study

Page 12: calibration equipment

- calibration should be done on curved blocks (verification of probe characteristics can be done on flat blocks)
- verification of calibration in time is necessary
- what is exactly meant by “at the end of each inspection”

Page 12: calibration probes

- what about calibration of the AMDATA probes
- tolerance of 2 mm should be tolerance of ± 2 mm

Page 13

- “the nominal angle for the shear wave probes ….” should read “the measured angle … should be within 2 degrees of the nominal angle”

Page 14

- emitter pulse amplitude depends upon frequency; settings of equipment should be given probe by probe
- gate settings should be verified
- replace “area to be scanned” by “volume to be inspected”
- inspected volume around counterbore not ambiguous
- probe mounting should be described in more detail; a drawing might be useful; zero-setting of probe should be mentioned
- full A-scans: RF or rectified?

Page 15

- table with probe sequence is ambiguous; should be reviewed completely

Page 16: through-wall sizing

- ambiguous; should be reviewed together when writing a decision tree

Page 16: characterisation

- characterisation will only consider following aspects: defect/non-defect, plane/volumetric, surface/non-surface breaking

Page 17:

- recording level should be explained better
- verify gate lengths

Page 18:

- reporting level to be clarified
- decision tree of how results will be evaluated should be described in much more detail, also if not ideal; this issue is considered to be very important and is the key of a successful qualification

APPENDIX 1B

WRITTEN COMMENTS RECEIVED FROM:

- PH. DOMBRET (AIB-VINCOTTE)
- R. CHAPMAN (NE)
- T. ZETTERWALL/P. KARLSSON (SQC)

ON THE ENIQ PILOT STUDY INSPECTION PROCEDURE (VERSION OF 18 NOVEMBER 1996)

EUROPEAN COMMISSION
EUR 19023 EN 73 pages

Editors: P. Lemaitre, B. Eriksen, M. Melbi

Luxembourg: Office for Official Publications of the European Communities

1999 – 73 pag. – 21.0 x 29.7 cm

Physical sciences

EN

Catalogue number: CD-NA-19023-EN-C

Copies of this ENIQ report can be obtained by writing to the following address:
JRC Petten
Institute for Advanced Materials
P.O. Box 2
NL – 1755 ZG Petten
The Netherlands

ABSTRACT

The present report gives the results of the qualification part of the first ENIQ pilot study. 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.

The Joint Research Centre

The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies.

As a service of the European Commission, the JRC functions as a centre of science and technology reference for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, private or national.

The JRC carries out Community research programmes decided by the Council and funded by the European Union budget with additional funding from associated countries. It also provides customer-driven research as scientific and technical support for other Community policies, such as those on the environment, agriculture or nuclear safety. It is involved in competitive activities in order to validate its expertise and increase its know-how in its core competencies. Its guiding line is that of "adding value" where appropriate rather than competing directly with establishments in the Member States.

Five separate sites, located in Belgium, Germany, Italy, The Netherlands and Spain, house the eight JRC institutes, each with its own focus of expertise.

The institutes produce their own Annual Reports, where readers will find more detailed information. The JRC also publishes numerous technical reports and contributes to scientific journals, presents papers to conferences and organises workshops to disseminate its scientific output. Further information can be found on the JRC website: www.jrc.org.