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ENIQ TGQ TECHNICAL DOCUMENT

PRACTICAL EXAMPLES FOR MANUFACTURING OF TEST PIECES FOR INSPECTION QUALIFICATION

ENIQ report No 44

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PRACTICAL EXAMPLES FOR MANUFACTURING OF TEST PIECES FOR INSPECTION QUALIFICATION

July 2011 ***ENIQ Report nr. 44*** ***EUR 24878 EN***

Approved by the ENIQ Task Group on Qualification

ENIQ, the European Network for Inspection and Qualification, publishes three types of documents:

Type 1 — **Consensus documents**
Consensus documents contain harmonised principles, methods, approaches and procedures and emphasize the degree of harmonisation between ENIQ members.

Type 2 — **Position/Discussion documents**
Position/discussion documents contain compilations of ideas, express opinions, review practices, draw conclusions and make recommendations for technical projects.

Type 3 — **Technical reports**
Technical reports contain results of investigations, compilations of data, reviews and procedures without expressing any specific opinion or evaluation on behalf of ENIQ.

This ‘ENIQ TGQ Technical Document - Practical Examples for Manufacturing of Test Pieces for Inspection Qualification’ (ENIQ Report No 44) is a type-3 document.

FOREWORD

The present work is the outcome of the activities of the ENIQ Task Group Qualification (TGQ).

ENIQ, the European Network for Inspection and Qualification, is driven by the nuclear utilities in the European Union and Switzerland and managed by the European Commission's Joint Research Centre (JRC). It is active in the field of in-service inspection (ISI) of nuclear power plants by non-destructive testing (NDT), and works mainly in the areas of qualification of NDT systems and risk-informed in-service inspection (RI-ISI). This technical work is performed in two task groups: TG Qualification (TGQ) and TG Risk (TGR).

A key achievement of ENIQ has been the issuing of a European Methodology Document, which has been widely adopted across Europe. This document defines an approach to the qualification of inspection procedures, equipment and personnel based on a combination of technical justification (TJ) and test piece trials (open or blind). The TJ is a crucial element in the ENIQ approach, containing evidence justifying that the proposed inspection will meet its objectives in terms of flaw detection and sizing capability. A qualification body reviews the TJ and the results of any test piece trials, and issues the qualification certificates.

This ENIQ TGQ Technical Document is a companion of Recommended Practice 5 (Issue 2). RP5 identifies issues to be considered when designing test-pieces for use in experimental inspection qualification trials and provides recommendations for conducting these trials and is intended to help plant owners, inspection qualification bodies, inspection designers and inspection vendors in the execution of their respective roles in the qualification process. The purpose of this Technical Document is to give examples of possible specific approaches to qualification in different application areas. More examples can be incorporated as time passes and experience grows. The examples were provided by individual ENIQ TGQ members. Any views expressed in the examples are those of these individual members, and not necessarily those of ENIQ as a whole.

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This ENIQ type-3 document was approved for publication by the ENIQ Task Group on Qualification. The document was edited by L Gandossi of IE-JRC.

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1 Introduction

This ENIQ TGQ Technical Document is a companion of Recommended Practice 5 (Issue 2)[1]. RP5 identifies issues to be considered when designing test-pieces for use in experimental inspection qualification trials and provides recommendations for conducting these trials and is intended to help plant owners, inspection qualification bodies, inspection designers and inspection vendors in the execution of their respective roles in the qualification process. The purpose of this Technical Document is to give examples of possible specific approaches to qualification in different application areas. More examples can be incorporated as time passes and experience grows.

The examples were provided by individual ENIQ TGQ members. Any views expressed in the examples are those of these individual members, and not necessarily those of ENIQ as a whole.

[1] ENIQ report 42, EUR 24866 EN, July 2011.

2 Recommendations and caveats on the reception of Test-Piece

Contribution by Etienne MARTIN, EDF, France.

Whatever the reason to use the results of an acquisition of a test block, for instance:

- Technical Justification of a Qualification Dossier;
- Capability assessment of a NDT System to fit for purpose;
- Validation of numerical models;
- Certification of personnel on blind tests, etc.

it is important that uncertainties in the manufacturing of the specimens which will serve as reference are controlled with the greatest care and are documented so that there is no incomprehension among all the recipients (Inspection Qualification Bodies, vendors, plant owners, etc.)

- To improve the level of accuracy on the dimensions and location of the manufactured flaws, through a maximum of "measurements" during the manufacturing process in order to know as precisely as possible the defect dimensions (sizing, location less than 0, 1 mm for example). The fingerprint by NDE methods at the end of manufacturing introduce or add its own lack of accuracy on the characteristic of the flaws. The procedure, to define the final dimensions of the flaws has to be documented avoiding so discussion with the vendors about the results obtained on the blocks during open or blind trials.

The measurement accuracy should better be better than manufacturing tolerances to allow for better correlation with subsequent NDE.

- If using specific techniques (fusion line by a laser beam, fatigue cracks, SCC, etc.), prior its use, the process has to be qualified by destructive examination.
- It is also necessary to define, according to the material of the test block if the "fatigue crack" has to be stabilized by over loading the block at the end of the cycling of the test piece.

3 Qualification of stress corrosion cracking near an austenitic weld root.

Contribution by Will Daniels, KANDE, United Kingdom

As an illustration of issues involved in selecting test-piece defects, consider an ultrasonic inspection for surface breaking (breaking the surface remote from that from which probes can be deployed), planar defects in the heat affected zone of an austenitic weld. This example inspection utilizes ultrasound scattered to the receiver probe by the crack face and corner for detection and diffracted crack tip signals for through-wall sizing. In this example case, characterisation is required to determine whether the defect is planar or volumetric and whether there is a ligament to the surface.

For the test-piece defect to accurately replicate the plant defect for detection assessment, the plant defect corner and surface roughness must be well replicated by the test-piece defect.

For the test-piece defect to be suitable for sizing capability assessment, it must replicate the edge shape and tip radius of the plant defect.

For the characterisation capability assessment in this example, the positional requirement should be relatively straightforward to replicate and the defect should have similar planar face character to the plant defect.

In this example, the detection criteria are based upon the scattered signal response amplitude and the sizing criteria on placement, appearance and amplitude of the tip signal.

One test-piece defect type used to replicate surface breaking defects is smooth electro discharge machined (EDM) slots. For defect species which are continuous along their lengths, smooth and planar, the corner can be fairly well replicated by an EDM notch (subject to replicating any inclination).

However unmodified EDM slots tend to have wide tips when compared to natural crack species such as those expected from fatigue or stress corrosion cracking. This would tend to give rise to larger signals from the upper end of the defect in the test-piece than would be expected from the plant defect's tip when examined with ultrasound.

Where the operator is required to apply some pattern recognition skills, the difference in form of the tip signals from the very regular EDM slot and the potentially more complex plant defect tips may be considered inadequate to adequately test key sizing skills. Were this to be the case, test-piece defects which better replicate the appearance of natural crack tips may be judged necessary.

As an extension to the above example, if the defects to be detected are stress corrosion cracking which can be heavily branched, have irregular depth profiles and are not necessarily continuous along their length, the difficulty arises that the defects themselves are difficult to simulate in test-pieces. Consequently there is likely to be

considerable variation in the appearance of the ultrasonic response signals even in similarly sized defects due to the complex morphological form.

On this basis the IQB may judge that capability needs to be generated on a relatively large population of defects. Suppose now that the geometric form of the component is complex, the test-piece fabrication exercise and effort in qualification can become very significant if the full-scale or holistic approach to experimental demonstration is applied.

Supposing the IQB wishes it to be demonstrated that there is likely to be adequate signal to noise level to enable detection of defects in a complex geometry inspection volume of the item, the IQB can assess this by demonstrating that there will be adequate sound intensity, appropriately orientated to detect defects of concern.

Coverage can be assessed using appropriate reference reflectors in a test-piece, which accurately replicates the form and material properties of the plant item. Scanning this specimen with the full inspection system would provide evidence of coverage, individual beam performance and amplitude redundancy.

However, it is necessary to demonstrate that for the anticipated defect type there will sufficiently strong response signals.

This information can be inferred from comparison of response data from typical defects of concern and the selected reference reflectors. The comparison information might be available in the literature, the vendor might be able to supply it, or a study might need to be commissioned to obtain the necessary assurance from, for instance, parametric specimens.

At this stage in the process, there is evidence supporting the capability of the inspection procedure, but it would still be necessary to confirm that the inspection could adequately analyse the complex response data anticipated from defects of this sort. In most cases this determination will be based upon human interpretation of response data.

It may be possible to make further use of parametric specimens, or of the data recorded from them, at this stage to test the interpretation skills and data analysis capability of the inspection.

Cases where a simple holistic demonstration could credibly be an appropriate solution include ferritic plant items such as pipes with fatigue or fabrication defects. Note that simple inspection cases may be demonstrated adequately entirely by technical justification possibly augmented by information from relevant, prior demonstration or other experimental data without recourse to a new experimental demonstration operation.

4 Example of Blind Trial Test Piece Manufacture at Rolls Royce (United Kingdom)

Contribution by Peter Kelsey, Rolls Royce, United Kingdom

With regard the manufacturing of defects for inclusion in blind trial test pieces it is found that where tip diffraction techniques are likely to be used for sizing then real defect implants provide a more realistic tip response than those from spark eroded defects. These however are costly and difficult to produce, an alternative approach is to place a metal coupon on the surface under test and TIG weld it in place. This provides for a smaller crack gape and more realistic crack tip with the ability to vary the surface finish on the side of the coupon which interfaces with the test surface. The manufacturer may be asked to generate test samples where welded in coupons have been destructively sectioned. This establishes the degree of weld infill and therefore the overall effect on the finished defect size. A report on the results is generated, together with those for radiographic and ultrasonic inspection of the finished test piece, and included in the component dossier. Subsequently if test samples of similar material and welding characteristics are required from the same manufacturer then further destructive analysis is not required. The verification aspect of the defect manufacturing process is extremely important in establishing the overall defect tolerances which we apply when assessing a Data Interpretation Engineers (DIEs) sizing results. To ensure defect integrity and position manufacturing hold points are designated i.e.:

1. Review destructive analysis results of trial defect implants.

2. Witness defect implant placement prior to over welding, and ensure they are in correct position according to the drawing or if they are not then take note of their current position for the record.

It is also ensured by way of a written instruction to the manufacturer that the correct material and welding procedures, as per the actual component, are used.

In terms of establishing what defects are implanted and where, the IQB normally holds a meeting with the technique developer in advance of the TJ being issued. This allows the developer to outline his likely technique approach and thus gives the IQB an idea as to areas of possible difficulty. This interactive approach also gives the developer an idea as to where defects should be placed in his own development test samples. It is important that both parties have a common understanding of worst case defect scenarios such that the optimum technique is developed and optimum qualification performed. It may also be found necessary to simulate the access and environment associated with the component under test. This is found to be especially important where limited access and high radiation dose levels are present.

In summary:

1. It may not be simply sufficient to just ask for conventional ultrasonic and radiographic inspection of the test piece in order to confirm defect placement and size. Where totally contained defects are required consideration should be

given to requesting destructive analysis of test samples of the same material and produced by the same method as that for the actual test piece. This will identify any weld infill associated with defect closure and thus allow a more accurate prediction of the tolerances associated with the finished defect size and position.

2. As cost is always an important consideration, thought should be given to combining, where possible, any open trial test piece with an associated blind trial test piece. An example of this is the case where an open and blind trial was required of an RPV studhole thread inspection technique. Open trial defects were placed in the upper section of the threaded region with blind trial defects placed in the lower threaded section. A lockable screwed plug was positioned over the blind trial section. This allowed access to the open defects but not to those for the blind trial.

3. Before the IQB can design and manufacture any blind trial test piece it needs to understand the intended inspection approach. This may be obtained from the technique developer by way of an outline technique definition document produced in advance of full technique development. From this together with the defect data sheet the IQB can determine the optimum location of artificial defects in the proposed test piece which best proves the technique.

4. As there is always the possibility that a blind trial test piece may throw up some anomalous results during a blind trial, it is suggested that data interpretation results from at least two data interpretation engineers (certified EN 473/ISO9712) be acquired and subsequently reviewed for validity by the IQB prior to the issue of any certification.

5. Where limited access and high radiation dose levels are likely to be experienced during a qualified inspection, it is important that the time it takes to complete any associated blind trial is noted. Should the time taken be excessive it may be necessary to revise the inspection approach in order to limit inspection time.

5 Assessment of Test Pieces for Practical Trials at EPRI

Contribution by Phil Ashwin, EPRI, USA

At EPRI each qualification requires an assessment of how test pieces will be used and how the conduct of test piece trials will occur. This assessment requires the qualification team personnel to follow instructions and processes. The following lists are the typical items considered. Readers may find these lists a useful aide when constructing instructions or checklists for similar purposes.

Test Piece Considerations
Input Information Needed for Design Basis
Document Industry Events
Document Industry Experience with NDE of these types of components
Document Flaw types, sizes, orientation from Industry OE
Determine Failure Mechanisms
Review Code or Regulatory Rulemaking Pertaining to Qualification of NDE
Survey Plant Design
Determine Scope
How many and what types of components are out there.
Complete list of nozzle types and names in existing fleet
Obtain design drawings
Develop list of unique outliers
Review Inspection & Evaluation Requirements or Guidelines for the Component type
Provide Technical Basis for NDE techniques needed for examination
Determine Test Sample Requirements
What minimum configurations are needed to cover the fleet based on plant design
Practice / Open Samples required?
Obtain engineering design inputs pertaining to flaw sizes, types and locations needed in qualification mock-ups
Consider First of a Kind Engineering (FOAKE) Sample Fabrication R&D
Sample R&D assessment
Determine valid method(s) for simulating the applicable flaw mechanism (how to build the flaws)
Review documentation relative to sample requirements with protocol or IP team
Determine elements of sample that will require R&D or validation of the manufacturing process
Identify manufacturing issues
Determine all flaw implantation processes for each orientation
Review plans with appropriate NDE technical personnel
Experimentation (if needed)
Trial implantations of all flaw types (includes drawings, PCS, etc)
UT and evaluation of trial flaw types
Documentation of trial sample process
Documentation of trial sample results
Communicate results with appropriate NDE technical personnel
Iterative steps needed to better define process for manufacturing
Document results in manufacturing specification (create new or modify existing if needed)

Fabrication (Incorporate FOAKE if necessary)
Design inputs
Collect all finalized information provided by Issues Program(IP) and Utility
Review, verify, and make sure information provided is understood and complete for manufacturing purposes
Iterative step of information gathering based on results of previous step
Design outputs
Construct shell configuration design drawing
Send out drawings for review and comment (EPRI, Utility, etc.)
Finalize and issue configuration design drawing
Determine the number of mock-ups needed based on IP and Utility criteria
Construct design drawings w/flaw distributions meeting given criteria
EPRI review of flaw distribution design drawings to ensure intent is being met
Finalized and issue flaw distribution design drawings
Compile a drawing package for quotation purposes
Execution of Fabrication
Send out Request for Quotation (RFQ)
Receive quotes from vendors
Evaluate vendor quotes
Convey Quotes to appropriate project personnel and decision makers
Award contract to vendor
Oversight of fabrication (iterative process)
Receive samples from fabrication vendor
Receipt Inspection
Documentation review
Fingerprint
DA and Grading Sheets - Grading Database
Inspection Technique Development (if necessary)
Confirm inspection methodology and design
Iterative step for Optimizing technique
Final evaluation of technique(s) and ordering of necessary equipment, etc.
Issue Certificate of Conformance
Transfer to Demonstration Program
Technical Management Tasks
Ensures all internal QA compliance and procedures
Performs formal assessment of NDE equipment necessary to Fingerprint samples
Delivery - Heads / Means of scanning / systems availability
Trained personnel to implement program and fingerprinting
Calibration / Reference Standards
Acquisition and Analysis systems
System Integration test plan
System testing
NDE/UT Techniques
Transducer Design Requirement
Confirm Transducer Design
Transducers available
Order/Receive Transducers
Calibration Reference Standards Fabrication (if needed)

Mock up design review considerations

- The Purchaser and Supplier shall agree upon who is responsible for the design drawings for the sample(s)
- Manufacturing travelers for the sample and hold points shall be established
- Scope and Purpose of mock-up understood and agreed upon by all parties
- Validate mock-up is fit for purpose (i.e. Blind, Open, R&D, Practice . .)
- Is this a Program Sample (is the sample to be integrated with other qualification results)
- What is the basis for adding it to previous program / qualification results
- Intended for Site Specific Mock up (One of a kind)
- Is the mock up intended for customers use - if so how will they use it
- Is the mock up intended for technique development
- Is a reference standard required to calibrate (Reference Standard) or can calibration reflectors be added to the sample
- Is the sample intended for Blind / Open qualification activities
- Has a unique Identification Number been assigned
- Are the major dimensions accurate, examples:
  - Sample Outside Diameter
  - Sample Inside Diameter
  - Wall thickness
- Are all of the design basis known and documented and usable as design inputs
- Is the mock up within Appendix VIII or applicable code tolerances (e.g. Thickness and Diameter) for intended use
- Have similar blocks been made
- Are there lessons learned from previous efforts to review
- Is the drawing format acceptable
- Are the views in sufficient detail to manufacture the sample
- Are the programmatic file naming conventions followed
- Scale defined on drawing title block or in independent views
- Are all "Revisions" labeled clearly
- Are "Views" clearly labeled or understood
- Is the 0° reference adequately captured
- Is the FLOW direction identified and true to rules relative to block type
- Is the "Weld Joint Geometry" accurate
- Are Welding materials for weld root, butter, clad, weld filler, weld overlay, weld repair, weld reinforcement, etc. evident and specified
- Are Base Materials and Form specified
- Has NDE been performed on the base materials or is additional NDE required
- Is the Sample manufacturing specification and current revision stated on the drawing
- Have all of the geometric characteristics been captured in the mock up
- Have all required welding positions been considered
- Have the welding procedures been approved that will be used
- Are weld prep and surface angles specified
- Are the proper tolerances stated
- Are there exceptions to the stated tolerances
- Are the tolerances achievable
- Are the tolerances measurable
- Is the mock up scanning and inside or outside (Ra< 6,3µm) surface finish specified
- Is HIP Process specified and why what cycle is required

- Are the failure mechanisms understood enough to manufacture a mock up
- Flaw Types Identified (e.g. Laser, Thermal, Mechanical, EDM)
- Is the Ratio of Alternative Flaws as compared to cracks acceptable
- Are there proper "Grading Units" for use within the qualification
- Does the key flaw attribute distribution and location meets all objectives of the mock ups basis
- Numbering and labelling of flaws matches visually to the matrix (if matrix is used)
- Are the flaw aspect ratios within reasonable bounds and representative of the failure mechanism
- Verify exam volume and the extent of scanning surface is appropriate
  - Consider the restriction of scan access post manufacturing versus by design of the sample
- Are flaws within exam volume and the sensitized material locations
- Will the flaws be used in TWS and are the extents of the flaw reasonable?
- Are branched flaws required
- Are the flaw tilts and flaw skews reasonable and appropriate
- Can the components of the mock up be machined with the dimensions provided
- Does Flaw Matrix (if used) or the drawing print out dimensions match the AutoCAD acquired dimensions from the ".DWG" file
- Is there a need for validation of any calculations used in the drawing
- Are SDH or EDH Reflectors needed for beam profiling
- Are the calibration needs addressed in the block or otherwise
- Are all flaws UT beam plotted to verify flaw usefulness
- Does UT beam steering need to be addressed
- Will the inspection of this mock up permit the application of the appropriate procedure without going beyond the intent of the inspection procedure or applicable criteria?
- Are all of the fabrication Hold Points Considered and noted on drawing

6 Defect simulation technique at the Swedish Qualification Centre (SQC)

Contribution by Håkan Söderstrand, SQC, Sweden

Examples on how to choose defects for UT and ET inspection for service induced defects.

According to studies done in Sweden the examples below are essential to consider regarding signal response for detection and sizing.

The tables below can be examples for essential parameters that should be considered when manufacturing artificial defects for a specific purpose. The tables are based on the defect type to be manufactured and the parameters that can influence the signal response from a defect based on the inspection technique to be used and therefore should be considered. These examples are done for: service induced defects - SCC, thermal fatigue and mechanical fatigue

The examples concerns Ultrasonic Pulse-Echo, Ultrasonic TOFD inspection and Eddy current inspection and are only given as examples to consider.

General parameters that can affect the signal response for UT and ET inspections

- Defect size
- Distance from expected defect to weld, bend or other obstacles
- Defect tilt
- Defect skew
- Grain size
- Microstructure
- Surface smoothness at defect surface
- Oxide at defect surface
- Defect profile in TWE

Table 1
Grading of defect parameters influence on UT-Pulse-Echo, SCC defects

SCC			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE			X
Shape at surface		X	
Amount of defects		X	
Defect branching			X
Defect width surface		X	
Defect width half depth		X	
Defect width crack tip			X
Radius crack tip			X
Ligament in depth	X		

Table 2
Grading of defect parameters influence on UT-Pulse-Echo, Thermal fatigue defects

Thermal fatigue			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE			X
Shape at surface			X
Amount of defects			X
Distance defect pattern			X
Defect branching		X	
Defect width surface		X	
Defect width half depth		X	
Defect width crack tip			X
Radius crack tip			X

Table 3
Grading of defect parameters influence on UT-Pulse-Echo, Mechanical fatigue defects

Mechanical fatigue			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE			X
Shape at surface		X	
Amount of defects		X	
Defect width surface		X	
Defect width half depth		X	
Defect width crack tip			X
Radius crack tip			X

Table 4
Grading of defect parameters influence on UT-TOFD, SCC defects

SCC			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE		X (1, 2)	
Shape at surface		X	
Amount of defects		X	
Defect branching		X (2)	
Defect width surface		X	
Defect width half depth	X		
Defect width crack tip			X
Radius crack tip		X	
Ligament in depth	X		

NOTES:
1) Influence only together with branching
2) Branching close to crack tip can considerably influence signal response

Table 5
Grading of defect parameters influence on UT-TOFD, Thermal fatigue defects

Thermal fatigue			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE		X (1, 2)	
Shape at surface			X
Amount of defects			X
Distance defect pattern			X
Defect branching		X (2)	
Defect width surface		X	
Defect width half depth	X		
Defect width crack tip		X	
Radius crack tip			X

NOTES:
1) Influence only together with branching
2) Branching close to crack tip can considerably influence signal response

Table 6
Grading of defect parameters influence on UT-TOFD, Mechanical fatigue defects

Mechanical fatigue			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE	X		
Shape at surface		X	
Amount of defects		X	
Defect width surface		X	
Defect width half depth	X		
Defect width crack tip		X	
Radius crack tip			X

Table 7
Grading of defect parameters influence on ET, SCC defects

SCC			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE	X		
Shape at surface		X	
Amount of defects		X	
Defect branching	X		
Defect width surface		X	
Defect width half depth	X		
Defect width crack tip	X		
Radius crack tip	X		
Ligament in depth	X		

Table 8
Grading of defect parameters influence on ET, Thermal fatigue defects

Thermal fatigue			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE	X		
Shape at surface			X
Amount of defects			X
Distance defect pattern			X
Defect branching	X		
Defect width surface		X	
Defect width half depth	X		
Defect width crack tip	X		
Radius crack tip	X		

Table 9
Grading of defect parameters influence on ET, Mechanical fatigue defects

Mechanical fatigue			
Defect parameter	Does not influence the signal response	Influences the signal response	Considerably influences the signal response
Shape in TWE	X		
Shape at surface		X	
Amount of defects		X	
Defect width surface		X	
Defect width half depth	X		
Defect width crack tip	X		
Radius crack tip	X		

7 Annex 1

Inspecta report: Guidelines for Design and Fabrication Documentation of Test piece and Flaws.

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GUIDELINES FOR

Design and Fabrication Documentation of Test piece and Flaws

CONTENT:

1. Purpose

The purpose of this document is to harmonize the design and fabrication documentation of test pieces and flaws. Harmonization of documentation minimizes errors and unnecessary work in all stages of documentation preparation and use.

This document complements but doesn't supersede SP 7 guideline. The document is collected from different sources and it will give examples of various aspects of test piece procurement and test piece documentation.

This document gives also content of documents, which should be included into fabrication documentation of test piece and flaws.

Due to great variation in test pieces and qualification cases, all aspects of this document may not be applicable to all cases.

2. Terminology

Skew	Angle with respect to weld either in parallel or transversal direction
Tilt	Angle with respect to normal of surface
EDM	Electrical discharge machining
Implant	Implanted crack
MFC	Mechanical fatigue crack
SC	Solidification crack
SCC	Stress corrosion crack
TFC	Thermal fatigue crack
WPS	Welding procedure specification

3. Structure and Format of Documentation

The documentation is delivered as a paper version and electrically in pdf or doc format. In addition, all drawings are delivered electrically in dwg or dxf format.

4. Design Documentation of Test piece

The manufacturing specification has to be prepared for the test piece. The design information of the test piece shall include at least following items:

- Drawing of test piece including material and weight information
- Welding documents of test piece
- Dimensions of base metal and material documents
- Detailed drawing of weld joint
- Drawing of calibration reflectors
- Description of planned flaws and their locations (preliminary flaw chart)
- Inspection plan for test piece during fabrication
- Instructions for stamping in test piece
- Plan for shields and transportation box
- Confidentiality and security declaration

4.1 Drawing of test piece including material and weight information

The test piece shall be planned and drawn up first in basic form. This draft drawing includes main dimensions of the test piece in order to enable design of flaw population and placement.

Possible need for permanent or temporary rails etc. required by the inspection technique shall be noted and accounted for in the test piece design.

4.2 Welding documents of test piece

The welding of the test piece shall be made using the same welding technique and filler material type as in welding of the inspection object itself. The welding of the test piece is not necessary to be qualified as welding of the inspection object itself.

WPS, pWPS or welding description of the test piece shall be included in the order documentation.

In appendix 3 there is a stripped-down model of WPS document.

4.3 Dimensions of base material and material certificates

The party, which is responsible for supplying the material, must also supply material certificates. In obtaining raw material care must be taken to specify all relevant material requirements. One relevant requirement is acoustic properties which should be approximately equal in the test piece and the inspection objects, and which should be defined as early as possible.

Material size (length) must be large enough for the test piece manufacturing after the drawings.

4.4 Detailed drawing of weld

The detailed weld drawing shall include machining of the weld groove, finishing of the weld surface after welding, length of the counter boring at the inner surface, roughness of the inner and outer surfaces etc.

The surface finish of the weld and the scanning areas shall be similar to the surface finish in the actual inspection object.

4.5 Drawing of calibration reflectors

If the inspection technique needs calibration reflectors, it is reasonable to locate notches in the test piece. In any case, the notches are useful in locating of defects and in measuring attenuation. Notches can be located at the end of the test piece on outer and inner surfaces so that they don't disturb scanning.

In appendix 2 there is an example how calibration notches are located and manufactured.

4.6 Inspection plan for test specimen

The utility/manufacturer (or equivalent) shall draw up an inspection plan for the test piece concerning manufacturing defects for trial. The inspection plan for manufacturing defects may consist of VT, PT, RT and UT inspections.

In sizing of flaws it is advisable to use manufacturing information and also NDT-methods as VT, PT, RT, UT, ET and replica technique.

4.7 Instructions for stamping in test piece

Test pieces shall be numbered by unambiguous way. Every test piece shall have own identification code.

The coordinate system of the weld and the reference point shall be defined and stamped on the test piece. It is necessary to mark the direction of measurement to avoid any misunderstanding when specifying places of flaws in direction of the weld.

When the location of the weld is not clear the place of the weld is stamped on the test piece so that the stamps do not disturb the scanning and the inspection.

4.8 Plan for shields and transportation box

There shall be a plan for shielding the blind test piece both during transportation and blind test itself. During transport of the blind test piece it shall be set into a sealed box (sealed by QB). During the blind test itself it may be necessary to shield a part of the test piece and there shall be a plan also for this case.

4.9 Confidentiality and security declaration

A confidentiality and security declaration shall be made before starting welding and also before sending documents (both issues concern blind trial pieces) to the manufacturer.

The manufacturer must produce the blind trial piece so that outside personnel has no possibility to see manufacturing and inspection of the test piece. A model of this declaration can be found in appendix 8.

The manufacturer shall look after that all workers, who are dealing with the flaws, give the confidentiality and security declaration.

5. Design Documentation of Flaws

5.1 Manufacturing specification of flaws

A manufacturing specification has to be prepared by the flaw manufacturer for each flaw type to be produced in the test piece.

The specification shall describe basic phases of flaw manufacturing, typical features of flaw and typical tolerances of flaw sizes (height, length and ligament thickness).

In the flaw specification the manufacturer may present also typical opening of crack mouth, face and crack tip based on validation results. Accordingly, typical opening of planar defects can be presented based on validation results.

5.2 Description of planned flaws and their locations

Different defects with their abbreviations are listed in paragraph 2.

The design of defects must be carried taking into account the input information and SP procedures and, if needed, data of the ASME XI Appendix VIII.

It is reasonable to use also smaller flaws than the detection target for showing real detection level. In addition, height distribution of flaws shall be wide enough for demonstrating the reliability of sizing in the volume of the qualification.

Locations of flaws in the test piece shall be such that flaws are not overshadowing each other and flaws can be detected.

A simple model of a preliminary flaw chart is stated in appendix 1. More complete picture of defect is in appendix 6.

Flaws can be presented also like in the next table:

Defect nr	Flaw type	Id/Od	Lo (parallel to weld)/ Tr (transversal)	Tilt [°]	Skew [°]	Location [mm]	Height [mm]	Length [mm]	Ligament [mm]
1 (A-side)	TFC	Id	Lo	5	0	17	8	20	0
2 (B-side)	MFC	Id	Lo	10	0	167	6	34	0

Flaws shall be mainly open into surface (inner surface of the piping test pieces) and in some cases they can be under cladding in ferrite part.

If this kind of table is used meaning of the ligament shall be clarified separately because ligament can be either the distance of the flaw and the surface or the distance of the flaw and the interface of the cladding and the base material.

Flaws can be parallel to weld or transversal and they may have also tilt/skew angles (see appendix 5) defined in the input information of the qualification procedure.

Especially, in the austenitic test pieces implanted crack samples are not accepted unless their suitability cannot be evidenced.

6. Fabrication Documentation of Manufacturer

In appendix 4 there is the list, which clarifies type, size and location of flaw. On base of this list the QB can afterwards make different lists for qualification purposes, for example the middle point of the flaw and measures as degrees.

Instructions for filling in the list are stated in appendix 5. If the weld is not symmetric, Y position can be defined from some other line than the centre line of weld, for exam-ple some corner of the bevel. In appendix 1 Y position is measured from the end of the test piece.

In appendix 6 there are stated three flaws and their filling in the list.

In tubular test pieces it is good to use degrees as well as distance measures from the reference point. The degree doesn't change when inspection is carried out from inner or outer surface.

The flaw manufacturer shall prepare the fabrication documentation of flaws and report the following information:

- estimation of sizes of all flaws with tolerances
- flaw list
- drawing or sketches of flaws and their locations and orientations

The flaw report may include PT indications of flaws (when possible) and flaw shape along the flaw length (when possible) as presented in appendix 7.

Flaw manufacturer may measure and report the crack mouth opening of surface crack as an additional information.

The manufacturer shall deliver the following documents

- Updated drawing of the test piece including main dimensions, material and weight information.
- Detailed drawing of weld, see item 4.4.
- Welding data of weld(s), see item 4.2 and appendix 3.
- Material certificates, see item 4.3.
- NDT-reports of weld(s), see item 4.6.
- Drawing of calibration reflectors, see item 4.5 and appendix 2.
- Report for stamping of test piece, see item 4.7 and appendix 5.
- Detailed drawing of each flaw including estimated and sized measures and tolerances by the manufacture(s).
- Drawing of flaws including types, locations and orientations of flaws. The information can be given in the list if the coordinate system is unambiguous and the manufacturer of the flaws has given detailed estimation of the flaws, see item 6.
- Confidentiality and security declarations, see item 4.9 and appendix 8.

The manufacturer(s) of the test piece shall submit all materials together with the test piece and destroy all own papers and electrical material of the test piece.

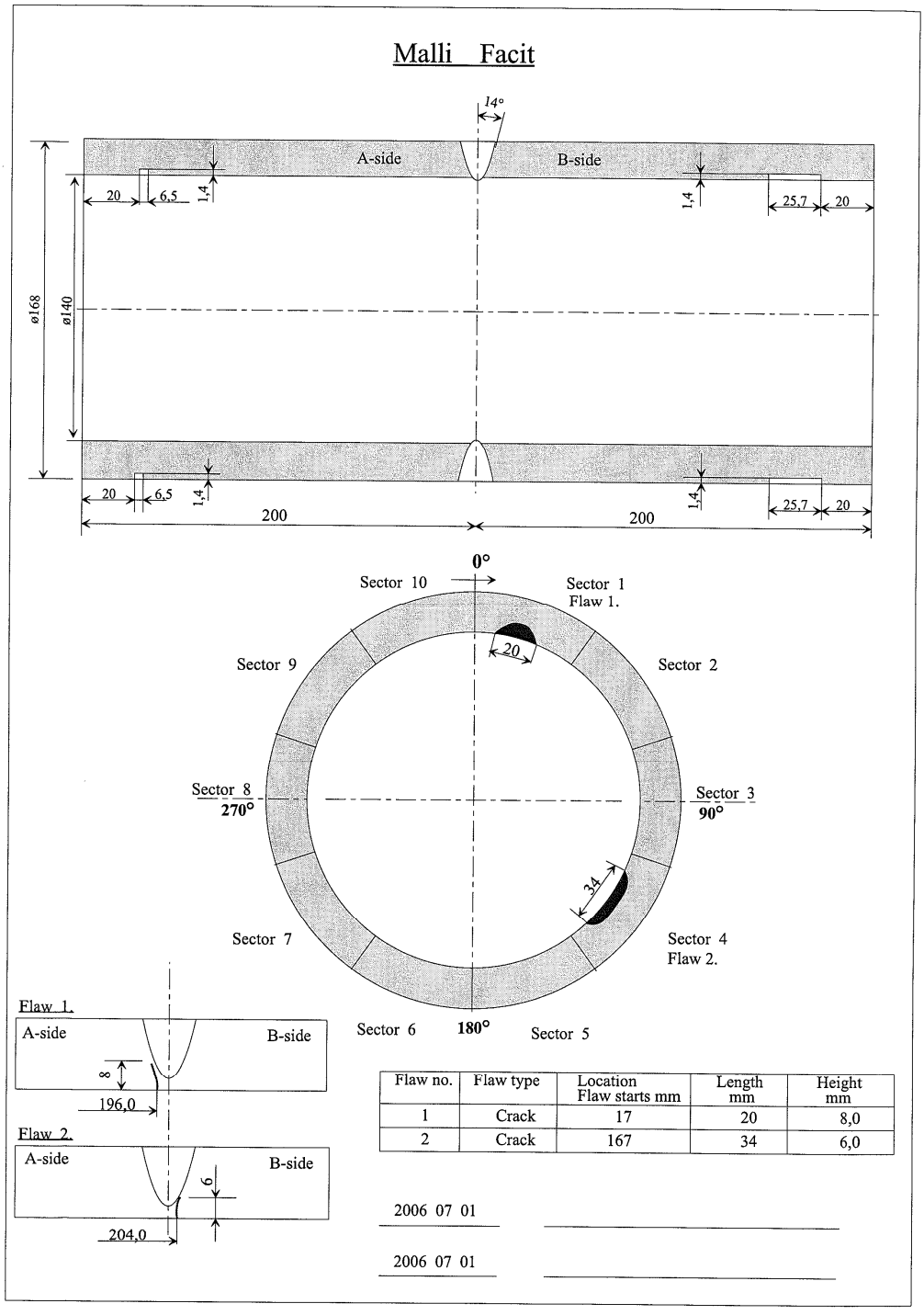
7. Final Documentation of Test Piece

The orderer of the test piece, the licensee or the QB shall complete documentation so that the final documentation shall include:

- Front page including:
  - name of qualification procedure
  - NDT-method using in trial
  - qualification object(s) including dimensions and materials
  - manufacturer(s) of test piece and flaws
  - manufacturing technique(s) of flaws
  - postulated types of flaws in object itself
  - the QB will complete the front page for the register
- Updated drawing of test piece including main dimensions, material and weight information
- Detailed drawing of weld,
- Welding data of weld(s),
- Material certificates
- NDT-reports of the weld(s)
- Drawing of calibration reflectors,
- Report for stamping of test piece,
- Drawing or sketch for rails of scanning system
- Detailed drawing of each flaw including estimated and sized measures and tolerances by manufacture(s)

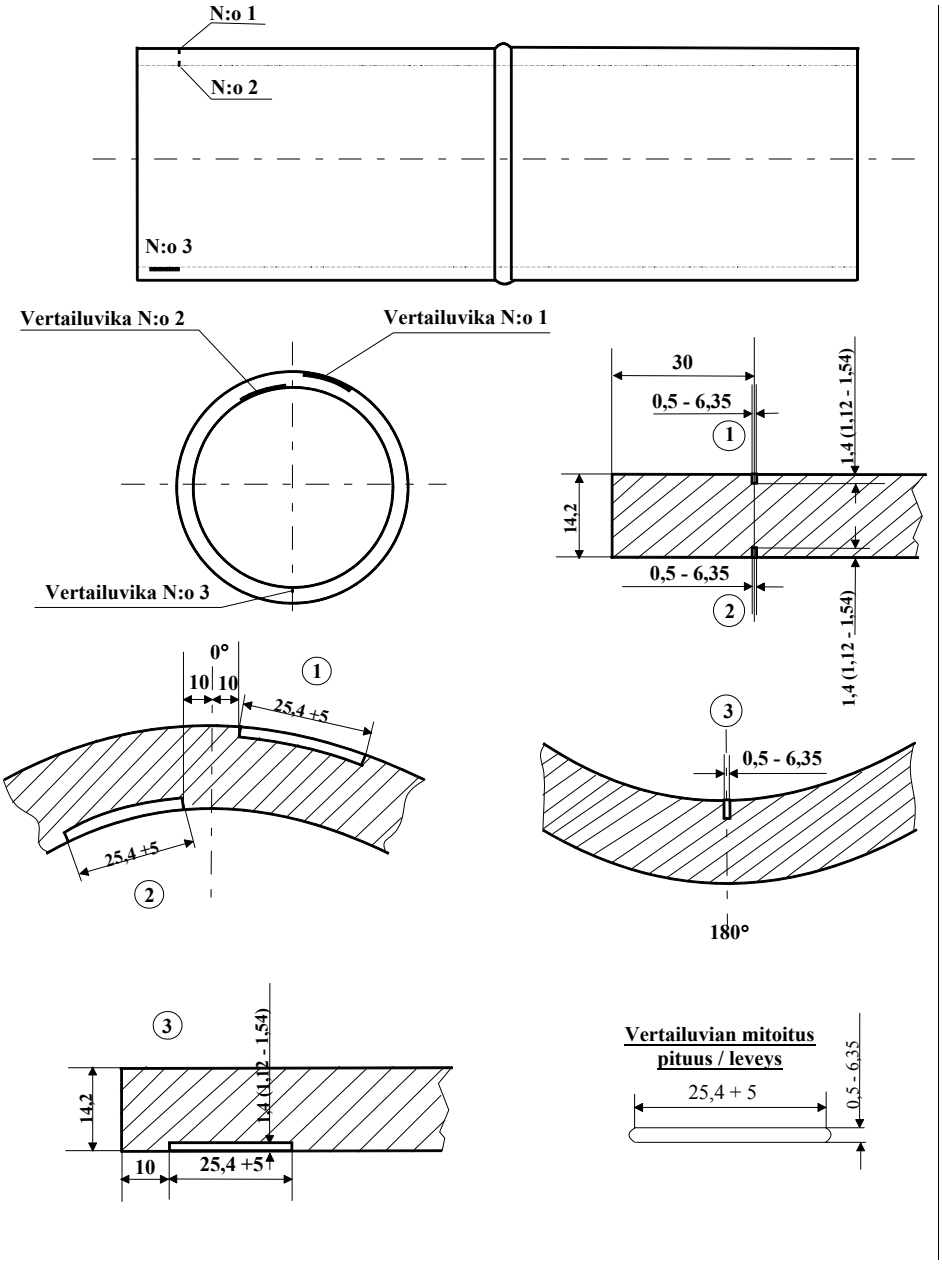
- Drawing of flaws including types, locations and orientations of flaws. Information can be given in the list if the coordinate system is unambiguous and the manufacturer of the flaws has given detailed estimation of the flaws
- Documentation for shields and transportation box
- Confidentiality and security declarations

Appendix 1 (simple model of flaw chart)



Flaw no.	Flaw type	Location Flaw starts mm	Length mm	Height mm
1	Crack	17	20	8,0
2	Crack	167	34	6,0

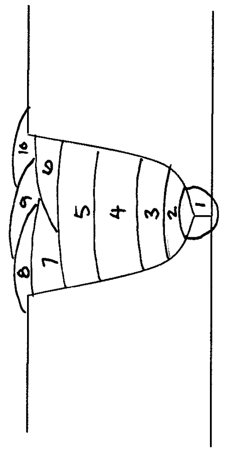
Appendix 2


N:o 1
N:o 2
N:o 3
Vertailuvika N:o 2
Vertailuvika N:o 1
Vertailuvika N:o 3
30
0,5 - 6,35
1
1,4 (1,12 - 1,54)
14,2
0,5 - 6,35
2
1,4 (1,12 - 1,54)
0°
10
10
25,4 +5
1
25,4 +5
2
3
0,5 - 6,35
180°
3
1,4 (1,12 - 1,54)
14,2
10
25,4 +5
Vertailuvian mitoitus
pituus / leveys
25,4 + 5
0,5 - 6,35

Appendix 3

Date & Time	Pass No.	Weld Posn	Filler Material Make	Cast No	Size ∅	Gas Type	Gas Flow Rate l/min	Welding Variables A	V	Wire Feed mm/min	Trav Speed mm/min	Interpass Temp °C	Info Entered By	Supervisor Approval
22.05.03	1	1G	N/A	N/A	N/A	Argon	12	95	-	-	-	-		
22.05.03	2 - 3	1G	Tigrod 16.32	419898WF0	2.00	Argon	12	95	-	-	-	-		
22.05.03	4 – 10	1G	63.30	8230331	3.25	N/A	N/A	108	-	-	-	-		

WELD PROCESS:- 1 - 3 TIG 4 – 10 MMA



Client INSPECTA OY	Weld No Sht 1 of 1
Sample No SFS - 01	Procedure No Appendix 3
	Post Weld Heat Treatment Carried Out:- N/A Spec No Signature Date

Appendix 4

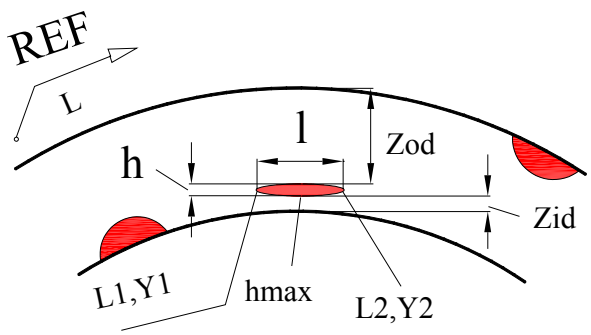
Test piece no	Open/ Blind	Dimensions	Materials	Date/Name	Signature

FLAW LIST

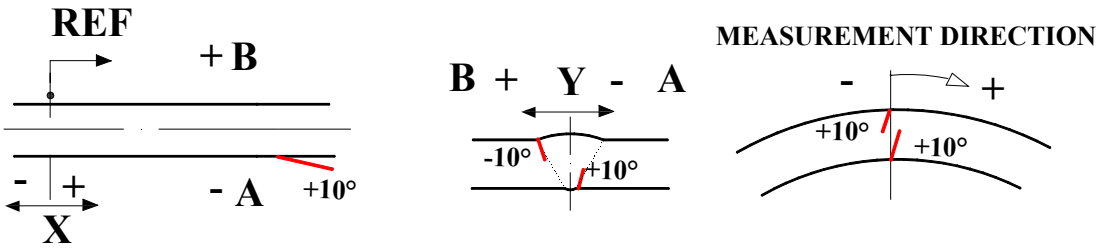
No	Flaw type	Id/Od surface	Height [mm]	Length [mm]	Skew [Lo/Tr ±°]	Tilt [±°]	L1 [mm/°]	Y1 [±mm]	L2 [mm]	Y2 [±mm]	Z id/od [mm]	Comments

Lo=parallel to weld Tr=transversal

Appendix 5

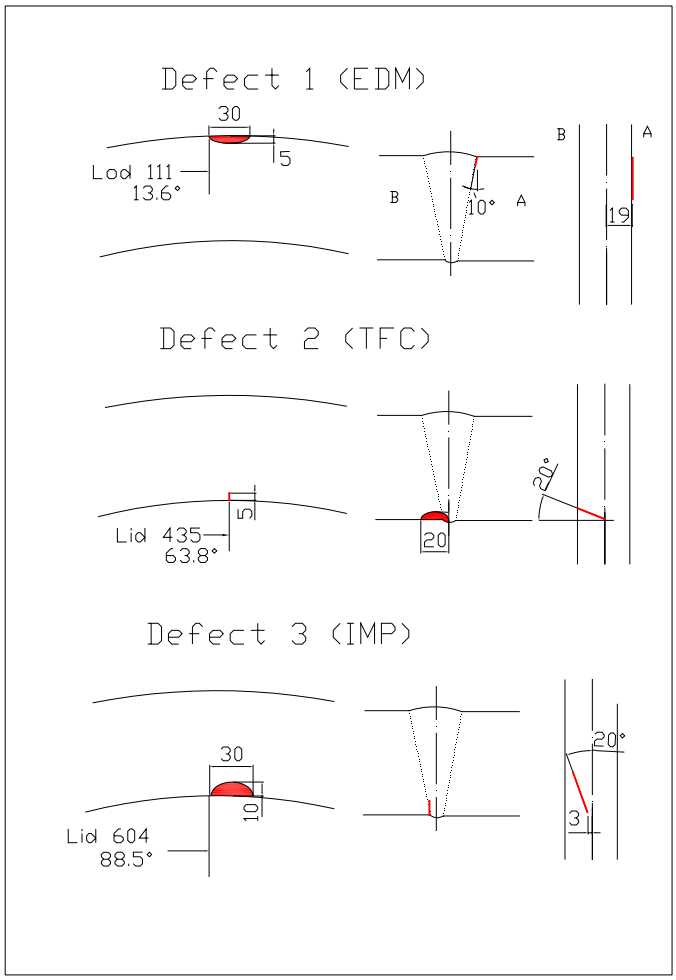


h=height (maximum)
l=length
L1=ref-staritng point of defect
Y1=centre line-starting point
L2=ref-end point of defect
Y2=centre line-end point of defect
Z=surface (od/id)-point in which h is maximum
od=outer diameter (surface)
id=inner diameter (surface)



Orientations of skew and tilt are defined by + and - marks.
Skew: See from A to B or in measurement direction.
Tilt: See in the same directions from the closest surface.
Positive = clockwise and negative = counter-clockwise.

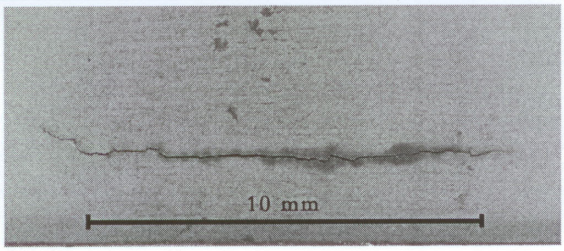
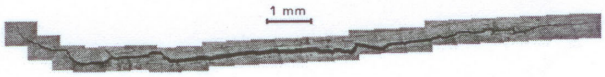
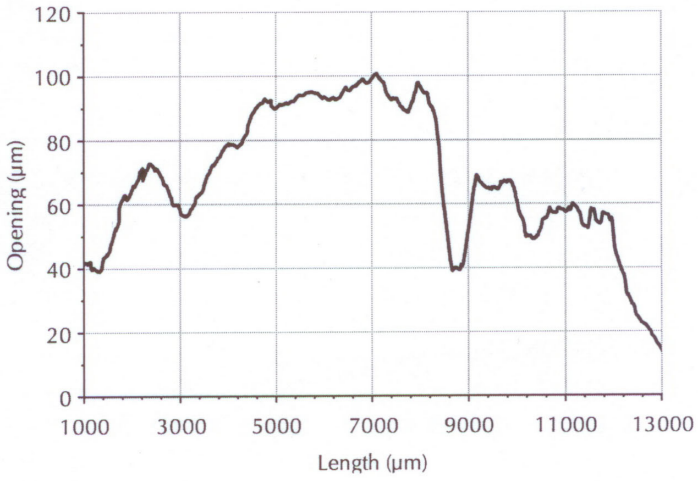
Appendix 6



NO	TyPE	Id/Od surface	Height [mm]	Length [mm]	Skew [Lo/Tr ±°]	Tilt [±°]	L1 [mm/°]	Y1 [±mm]	L2 [mm]	Y2 [±mm]	Zod/id [mm]	Commets
1	EDM	Od	5	30	Lo	+10	111/13,6	-19	141	-19	0	
2	TFC	Id	5	20	Tr +20	0	435/63,8	0	442	+19	0	
3	IMP	Id	10	30	Lo -20	0	604/88,5	+3	632	+13	0	

Appendix 7

ANNEX 3. DETAILED FLAW DESCRIPTION

XXXXXXX	
PT-image	
Crack profile	
Opening at the surface	
Opening profile of the surface opening	

Appendix 8

inspecta sertifiointi

CONFIDENTIALITY STATEMENT 1 (1)

CONFIDENTIALITY AND SECURITY DECLARATION

Inspecta Sertifiointi Oy as the qualification body requires that the information of blind test specimens can be handled only authorized persons. That's why Inspecta Sertifiointi asks you to accept the following condition by signing this declaration.

Inspecta Sertifiointi will marked the information of blind test specimens as strictly confidential.

XXXX will authorize persons who can handle this confidential information. The number of persons should be minimizing. The authorized persons and the representative of XXXX have to sign this declaration. After signing the declaration has to send to Inspecta Sertifiointi Oy.

If the loss of secrecy will occur, XXXX has full responsibility to correct the situation (e.g. produce new test specimens).

I the undersigned hereby declare never to disclose or reveal any information relating to blind test specimens planned by Inspecta Sertifiointi in particular flaw distribution, size and locations except to the flaw manufacture and the authorized persons and that all information will be treated as strictly confidential.

I also guarantee that the confidential material will be returned to Inspecta Sertifiointi or in case of e-mail deleted when it is not any more needed or Inspecta Sertifiointi asks it.

Date and place _____

Name _____

Signature _____

Authorised by _____ (XXXX)

◆ PL 94, 02151 ESPOO ◆ MIESTENTIE 3 ESPOO ◆ PUHELIN 010521600 ◆ FAKSI 0105216750 ● Y-TUNNUS 1065745-2

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European Commission

EUR 24878 EN – Joint Research Centre – Institute for Energy
Title: ENIQ TGQ TECHNICAL DOCUMENT - PRACTICAL EXAMPLES FOR MANUFACTURING OF TEST PIECES FOR INSPECTION QUALIFICATION

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Abstract
This ENIQ TGQ Technical Document is a companion of Recommended Practice 5 (Issue 2). RP5 identifies issues to be considered when designing test-pieces for use in experimental inspection qualification trials and provides recommendations for conducting these trials and is intended to help plant owners, inspection qualification bodies, inspection designers and inspection vendors in the execution of their respective roles in the qualification process. The purpose of this Technical Document is to give examples of possible specific approaches to qualification in different application areas. More examples can be incorporated as time passes and experience grows. The examples were provided by individual ENIQ TGQ members. Any views expressed in the examples are those of these individual members, and not necessarily those of ENIQ as a whole

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