JRC Scientific and Technical Reports

Institute for Energy

ENIQ RECOMMENDED PRACTICE 2

Strategy and Recommended Contents for Technical Justifications

Issue 2

ENIQ report No 39

ENIQ

European Network for Inspection and Qualification

JRC EUROPEAN COMMISSION

Institute for Energy

EUR 24111EN – 2010

The mission of the JRC-IE is to provide support to Community policies related to both nuclear and non-nuclear energy in order to ensure sustainable, secure and efficient energy production, distribution and use.

European Commission
Joint Research Centre
Institute for Energy

Contact information
Address: Westerduinweg 3, NL-1755 LE Petten
E-mail: thomas.seldis@jrc.nl
Tel.: +31.224.565132
Fax: +31.224.565641

http://ie.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

JRC55643

EUR 24111EN
ISBN 978-92-79-08425-6
ISSN 1018-5593
doi:10.2790/16420

Luxembourg: Publications Office of the European Union

Printed in The Netherlands.

European Commission
Directorate General Joint Research Centre
Institute for Energy
Petten, The Netherlands

ENIQ RECOMMENDED PRACTICE 2:

STRATEGY AND RECOMMENDED CONTENTS FOR TECHNICAL JUSTIFICATIONS

June 2010 ***ENIQ Report nr. 39*** ***EUR 24111 EN***

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.

The present document “ENIQ Recommended Practice 2: “Strategy and recommended contents for technical justification” (ENIQ Report nr. 39) is a Type 1 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 and TG Risk.

A key achievement of ENIQ has been the issue 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 defect detection and sizing capability. A qualification body reviews the TJ and the results of any test piece trials and it issues the qualification certificates.

The aim of this Recommended Practice is to assist those tasked with producing a TJ to identify the role of the TJ in the overall qualification process and hence to identify the material that should be included in it. It also aims to promote the harmonisation of practices and the transferability of qualifications between countries by defining a uniform format for TJ documents. This document combines the contents of, and therefore replaces, two previous recommended practices, RP2, Issue 1, and RP3, Issue 1 and which separately dealt with the issues of TJ contents and TJ strategy respectively.

The members of the ENIQ Task Group on Qualification are:

I Atkinson	KANDE International, United Kingdom
G Bollini	Tecnatom, Spain
R Booler	SERCO, United Kingdom
R Chapman	British Energy, United Kingdom
W Daniels	KANDE International, United Kingdom
L Horácek	NRI- Řež, Czech Republic
M Horváth	Slovenské Elektrárne, Slovakia
A Jonsson	Forsmark NPP, Sweden
P Kelsey	Rolls-Royce Marine Power, United Kingdom
P Kuusinen	Teollisuuden Voima OY, Finland
H Martinsen	Ringhals NPP, Sweden
D Moussebois	Laborelec, Belgium
B Neundorf	Vattenfall Europe Nuclear Energy, Germany
R Schwammberger	Kernkraftwerk Leibstadt, Switzerland
T Seldis	JRC, European Commission, The Netherlands
H Söderstrand	SQC Swedish NDT Qualification Centre, Sweden
J Pitkänen	Posiva, Finland

This ENIQ type 1 document was approved for publication by the ENIQ Steering Committee. The main author of this report is Ian Atkinson of KANDE International. The document was edited by Thomas Seldis and Luca Gandossi of IE-JRC.

The voting members of the ENIQ Steering Committee are:

R Chapman	British Energy, United Kingdom
P Dombret	Tractebel, Belgium
E Martin	EDF, France
K Hukkanen	Teollisuuden Voima OY, Finland
R Schwammberger	Kernkraftwerk Leibstadt, Switzerland
B Neundorf	Vattenfall Europe Nuclear Energy, Germany
J Neupauer	Slovenské Elektrárne, Slovakia
S Pérez	Iberdrola, Spain
U Sandberg	Forsmark NPP, Sweden
P Kopcil	Dukovany NPP, Czech Republic
D Szabó	Paks NPP, Hungary

The European Commission representatives in ENIQ are T Seldis and L Gandossi.

TABLE OF CONTENTS

This page is intentionally left blank.

1 Introduction

The European Methodology Document [1] provides a general framework for the development of qualification for the inspection of specific components to ensure they are developed in a coherent and consistent way while still allowing qualification to be tailored in detail to meet different national requirements. Qualification of a non-destructive test may require assessment of all or any part of a NDT system, composed of a combination of NDT procedure, equipment and personnel. This qualification or assessment is to be considered as the sum of the following items [1]:

- Technical justification (TJ), which involves assembling convincing evidence on the effectiveness of the test including previous experience of its application, experimental studies, mathematical modelling, physical reasoning and so on

- Practical assessment in the form of open and, where necessary, blind trials conducted on test pieces representative of the component to be inspected.

The European methodology does not give a detailed description of how the inspection of a specific component should be qualified. Instead, the appropriate mix of the above sources of evidence must be judged separately for each particular case. The use of technical justification to justify the selected inspection system against the inspection input parameters and thereby minimize the requirement for costly and time consuming practical trials is central to the process. More detailed information on how to apply the general principles for inspection qualification developed in the European methodology document is available in a series of 'Recommended Practices' of which this document is one.

An ENIQ Recommended Practice is a document produced by ENIQ to support the production of detailed qualification procedures by individual countries and is the next level of document below the methodology. Recommended Practices are applicable in general to any qualification. This general scope means that valuable advice can be given by ENIQ to promote a uniform approach to qualification but the detail of how qualification is to be done is determined at the national level in line with the regulatory and technical requirements in each country. Organisations are free to make use at national level of the existing Recommended Practices, as they see fit.

The aim of this Recommended Practice is to assist those tasked with producing a TJ to identify the role of the TJ in the overall qualification process and hence to identify the material that should be included in it. It also aims to promote the harmonisation of practices and the transferability of qualifications between countries by defining a uniform format for TJ documents. This document combines the contents of, and therefore replaces, two previous recommended practices, RP2, Issue 1 [2], and RP3, Issue 1 [3] and which separately dealt with the issues of TJ contents and TJ strategy respectively.

Definition of a TJ

TJs are used for a number of purposes and are not readily defined by a single definition, but at a simple level it is possible to say that:

> The purpose of a TJ is to examine a specific proposition and to present properly reasoned logical arguments, backed-up by verifiable, good quality evidence, which support the proposition and demonstrate this in a way that can be understood and assessed by a knowledgeable reader with suitable experience.

For example: In ultrasonic inspection the proposition might take the form: “This inspection procedure will reliably find all circumferentially orientated fatigue cracks larger than 5mm high x 15mm long, with tilts within 5° of the through-wall direction, in austenitic stainless steel pipes with diameters in the range 100mm to 200mm and wall thickness T such that 20mm ≤ T ≤ 60mm”. The associated TJ would then have to present evidence that gives a sufficient degree of proof that the claimed performance is achievable with the stated inspection procedure under the conditions in which the inspection will be applied.

The example above illustrates one of the most common forms of the TJ, where it is used to justify the application of a particular inspection procedure to inspect a specific component or range of components for specific flaws. The TJ applies only to the specific inspection situation, the input parameters of which should be known at the outset.

Another common form is where the TJ is used to argue that some change to a qualified inspection system does not invalidate the qualification. For example, where an inspection procedure has been qualified using a specific piece of inspection equipment A and it is subsequently decided to use a different equipment B, it may be necessary to prove that the performance of equipment B, in the particular application to which it is to be applied, is at least as good as that originally obtained with equipment A. This argument can be made in a TJ and could consist of a reasoned argument based on the performance characteristics of A and B, demonstrating that in terms of each of the essential parameters of the inspection, B will have the same or better performance than A. Alternatively, the results of an empirical trial showing that A and B give equivalent performance when applied to a representative test specimen could be presented. In some cases it may be most appropriate to use a combination of these two approaches and to have physical reasoning backed up by small scale empirical trial results.

The content of the TJ is determined by the use to which it will be put, the component, the novelty of the inspection involved and the level of rigour required. This is discussed more fully in Section 2. When the proposition being justified is relatively simple, those sections of the recommended contents list that are not relevant to the argument presented may be omitted or truncated.

Section 2 summarises the recommended contents for a TJ and identifies the different sections it might contain. The order of these sections is arranged to present a coherent and logically progressive picture to the Qualification Body that must assess the TJ. It is unlikely that the writer of the TJ will be able to address the issues necessary in the same order. Neither, except in the simplest cases, should the writer expect to generate the entire TJ from available information. It is more likely that production of the TJ will raise questions regarding the component, the defect specification and the inspection procedure that will require investigation, clarification and perhaps modification before it can be completed. For this reason it is important that preparation of the TJ starts early in the overall qualification process. In this way it can help to refine the inspection procedure by identifying weaknesses at an early stage. It can also identify the need for further studies, including practical trials or mathematical modelling, that might be needed to support the arguments to be presented within the TJ and, through the identification of worst-case defects, it can provide valuable input on the design requirements for any open and/or blind trial test-pieces that might be needed to complete the qualification.

As stated above, the purpose of a TJ is to present a convincing explanation of how and why the intended inspection will be capable of achieving the intended inspection aims. It should do this by reference to physical reasoning and logical argument based upon verifiable information and evidence. This evidence can come from a range of sources,

including experimental trials and procedure development work, published information from conference proceedings and journals, information presented in internal reports and from previous experience, provided that the claims made are verifiable. It is important that the TJ should not rely on unsubstantiated or unverifiable assertion, nor should it attempt to hide or play down any identified weaknesses or limitations of the inspection or of the TJ itself, as such information could be of vital importance to other aspects of the overall component assessment.

Appendix 1 gives more detail about the content of the different sections of the TJ.

It is intended that this Recommended Practice should be relevant to any non-destructive testing method. However, because the area in which qualification has been applied most frequently is ultrasonics, where examples are given for purposes of clarification, these are generally drawn from ultrasonic applications. It should also be emphasised that although this particular document was originally developed specifically for in-service inspection of nuclear power plant components, the principles given in it can be used for qualification of manufacturing inspections or for inspections performed in the non-nuclear field.

A glossary of definitions used in ENIQ documents is available [4].

2 Role and definition of the TJ

2.1 Role of the TJ in the overall qualification process

The aim of the ENIQ Methodology is that practical assessment and technical justification should together provide convincing evidence that the inspection will achieve the desired level of performance, which will often be defined in terms of defect detection, sizing and characterization capabilities. The balance between these elements will depend upon the details and importance, whether in terms of safety or value, of the component for which the inspection qualification is being performed. In general, the more important the component, the greater the technical difficulty of inspection, the greater the adverse consequences likely to result from poor inspection and the greater the difficulty of producing convincing technical arguments from modelling or existing experience, the more likely it is that a substantial degree of practical assessment will be required. For example, a relatively simple inspection, such as the detection of defects in butt welded carbon steel pipes, using standard pulse-echo ultrasonic techniques, may be entirely justifiable by TJ. In contrast, an inspection to detect and size stress-corrosion cracking defects in small diameter austenitic stainless-steel nozzle to cast austenitic pipework welds, is likely to require extensive practical demonstration.

The TJ forms a key part of the ENIQ approach to qualification. This is because it is normally not practicable to construct a convincing argument for inspection capability using results from test piece trials alone, due to the large number of defects and/or independent measurements that would have to be made to achieve a statistically valid result. The combined use of TJ and test piece trials, which are complementary, allows a convincing case for inspection qualification to be presented without the need to manufacture very large numbers of test pieces. It should be noted however, that an unavoidable corollary of this approach is that greater reliance is placed on the expert judgement of both the TJ writer and the Qualification Body personnel responsible for assessing it.

The TJ helps to make a convincing case by presenting evidence from sources other than fully representative practical trials. By doing this, it reduces the need for practical trials, which tend to be expensive and time-consuming. The TJ also adds value because it includes analysis based on an understanding of the underlying physics of the specific inspection, which is gained, for example, through physical reasoning (qualitative assessment), mathematical modelling (quantitative assessment) and/or experimental parametric studies. By identifying the capabilities and weaknesses of an inspection procedure, the TJ can also assist in the design of effective qualification test pieces, by providing data which can be used to ensure that any test pieces to be used in trials focus on those defects or configurations which present the greatest inspection challenges, taking into account the identified essential parameters related to the input information. This is one reason why it is very important that the TJ is addressed early in the qualification process.

The TJ also has an important role to play in helping to demonstrate that the inspection system will perform as expected over time. It does this by identifying the essential parameters of the system and the calibration and system checks that will be used to ensure that the demonstrated capability is maintained during use.

2.2 Use of the TJ in NDT system qualification

In NDT system qualification (where "NDT system" means all those elements, including procedure, equipment, software and personnel, which can influence the outcome and quality of the inspection), the TJ can be defined as the collection of all the necessary

information which provides evidence that the NDT system can meet its stated objectives. Its purpose is:

- To overcome the limitations of a limited number of test pieces.

- Where necessary, to generalise any practical trials results by demonstrating that, if the test piece trial results meet the performance requirements, this implies that similar results could have been obtained for any other of the possible configurations.

- To provide a sound technical basis for designing efficient test piece trials.

  As test piece trials are performed on a limited number of defects, it is important that the defects used are selected so that the test piece trials provide the greatest possible added value to the qualification. The TJ can provide evidence which helps the Qualification Body/Utility to design the test pieces by identifying the "worst-case defects" which present the greatest challenges for the specific inspection being considered. The design of test pieces is discussed in RP5 [5].

- To provide a technical basis for the selection or justification of the essential parameters of the NDT system and their valid range.

  There are many parameters which can potentially influence the outcome of an inspection. Some relate to the input information (component, defects to be detected, etc) and some to the inspection system (probe beam angle, recording level, digitisation rate, timebase linearity, etc). The identification and treatment of influential parameters in a TJ is discussed in Recommended Practice RP1 [6].

It should be noted that the degree to which the TJ treats the performance of the NDT system in terms of its influential parameters can have a big influence on how future changes to the inspection system might be handled.

For example, it is likely to be easier and therefore cheaper initially, to demonstrate in a qualification that a particular inspection instrument and a defined set-up is capable of detecting some specific defect, than it is to explore fully what is needed to detect this defect in terms of all the separate essential variables of the system. However, a change of inspection system, or even of the set-up, would then invalidate the qualification making a new qualification exercise necessary. If, however, the inspection system performance has been adequately described in terms of its influential parameters, it may only be necessary to show that the alternative system or set-up remains within the demonstrated range, which would make re-qualification unnecessary or at least reduce the requirements for re-qualification. This is a commercial decision and is likely to depend upon the likelihood and the number of times that the inspection will need to be repeated in the future. For a one-off inspection there may be little point in identifying the full range of conditions under which adequate performance can be obtained, one set of conditions being sufficient for the intended purpose. However, where an inspection is likely to be used regularly over many years of plant operation, it makes more sense to perform a full influential parameter analysis at the first qualification, as this is likely to make it easier to maintain that qualification over the lifetime of the inspection.

2.3 Other purposes of the TJ

As well as their use in NDT system qualification, TJs have other applications in providing evidence and demonstrating, through logical argument, that an inspection will achieve the required performance criteria. Each different category of application will require a TJ

of a different type or style, containing different types of evidence. The aim of this section is to provide examples of these different types of TJ, according to their intended application. Applications for which TJs might be used are:

- To justify the use of any intended test pieces and defect populations

  This type of TJ aims to demonstrate that the test pieces chosen by the Qualification Body, and the types of defects they contain, are realistic simulations of the actual component that is to be inspected and are appropriate for the inspection techniques that are to be applied (ET and UT inspections for example, are likely to have different defect requirements)..

  For example, where, for reasons of cost, or ease of manufacture, it is proposed to use test pieces of simplified geometry, or to use simplified defect implantation techniques, the main purpose of the TJ will be justifying the extrapolation of the results obtained on these test pieces to the actual geometries and defect types of the plant to be inspected. A related use might be the justification of the particular selection of worst-case defects made for a particular inspection. In this case, the TJ would concentrate on demonstrating that the worst case defects to be introduced into the test pieces really are the most challenging defects.

  It should be noted that this type of TJ differs from most of the other types considered here, in that its production, particularly in the case of blind trial test pieces, will be the responsibility of the Qualification Body rather than the plant owner or the inspection vendor. Open trial test pieces however, may be produced by the plant owner or vendor following an analysis of worst case defects and justified in the inspection TJ (and then be subject, of course, to Qualification Body assessment).

- To justify the use of inspection equipment

  This type of TJ presents evidence from design processes, functional testing and commissioning trials in order to demonstrate that the inspection equipment, including manipulators, data acquisition systems and data processing systems (including software), is capable of fulfilling the requirements specified in the inspection procedure.

- To justify the use of inspection procedures

  This is essentially a limited scope version of that discussed in Section 2.2 and typically, such a TJ presents evidence from physical reasoning (qualitative assessment), computer modelling of coverage and defect response, experimental studies and other sources, to support the procedure's ability to fulfil the objectives of the inspection.

- To extend an existing qualification

  This type of TJ arises in cases where it is desired to extend an existing qualification to a new situation. If the new situation is not very different from the old, it will usually be possible to carry out this extension through TJ alone, or with only minimal new test-piece trials. Examples include TJs for the following applications, where the aim should be to compare the essential parameters of the existing qualification with the essential parameters of the new qualification. In these cases, the greater the difference in the essential parameters, the more likely it is that supplementary test-piece trials will be necessary:

- To extend qualification from one component to another similar component.

  For example, if an inspection has previously been qualified for welded joints in a 150mm diameter ferritic steel pipe, it should be possible to extend the qualification to include welded joints of the same design and similar thickness in a range of pipe diameters, by the use of physical reasoning based upon the application of any appropriate standards and evidence available in published reports.

  It is also worth noting that TJs may sometimes be written from the outset to cover a group of components, for example components of similar geometry and dimensions. Such a TJ may enable a single set of test pieces to be used to qualify a range of component geometries. This is a similar situation to the case above; the difference being that here it is decided from the outset to group the different component geometries requiring qualification in order to reduce the number of test piece trials and TJs required.

- To extend qualification to a new material structure

  In a similar way to the above, an inspection may have been qualified for a particular material structure, and it may be desired to extend it to a component of the same geometry but with a different material structure, such as might occur if welding is carried out in a different position. This situation applies particularly to the ultrasonic inspection of austenitic welds or cladding. In such cases, it may be beneficial to perform small scale experimental trials to provide evidence specific to the situation under consideration.

- To cover changes and upgrades in equipment or software

  This is a situation that arises frequently in practice, as equipment becomes obsolete or software is upgraded to a new version. In general, small, evolutionary changes that improve equipment capability should be justifiable by reasoning alone. More radical changes, such as changing from one inspection system to another from a different manufacturer, are likely to require some level of practical trial to demonstrate that the required level of performance, in terms of the essential parameters of the system, is maintained.

- To address changes in the defect description

  For example a new defect type may have emerged that was not envisaged at the time of the original qualification and hence the inspection is not qualified for this defect type. However, provided the new defect type is not radically different to the existing defect types, so that the essential parameters remain the same or similar, it may be possible to extend the qualification by physical reasoning, parametric study or limited empirical trials.

- To extend a qualification to cover inspection at a different plant

  Many qualifications are plant specific, but where plants have the same or similar designs and the defects of concern are similar, TJs can be used to extend an existing qualification from one plant to another. Whilst this is clearly most practicable where both qualifications fall under the jurisdiction of a single Qualification Body, in principle this type of TJ could be used to address the recognition of qualifications across national boundaries.

It should be noted that many TJs extending existing qualifications may need to combine elements of several of the types discussed above.

2.4 General recommendations for the contents of different types of TJ

This section attempts to indicate what information needs to be included in the different types of TJ that might be produced.

2.4.1 General scheme for the contents of a TJ

The precise content of the TJ must be determined on a case by case basis depending on the particular application of the TJ and the component and inspection involved, together with the level of detail required.

The TJ can be composed of the following sections, although in general, not all the sections listed will be required in every TJ. For consistency between different TJs, it is recommended that the section numbering system below is always used and that any sections not needed are still included as section headings and marked as 'not applicable'.

The relationship between these sections and with other elements of the qualification process is shown in Figure 1. It should be noted that the figure does not represent a flowchart, the sections are not necessarily completed in order and it is likely that feedback resulting from completion of certain sections will make it necessary to revise other sections in order to achieve a fully consistent TJ.

Summary

A short summary should be given explaining the purpose of the TJ and stating how well the inspection objectives are met. Any limitations of the TJ should be mentioned also.

Section 1: Introduction

This section should provide an introduction to and outline description of the inspection to be justified, including components to be inspected, defect types to be sought and inspection methods to be applied.

It should also describe the scope and layout of the TJ and any deviations from the ENIQ model.

Section 2: Summary of Relevant Input Information

This section summarises the input information; that is, all the necessary information concerning the component to be inspected, the defects to be detected, any arduous environmental conditions, the inspection method that will be used and the inspection objectives to be met.

If all required information is not available and there is a need to progress the TJ, then assumptions need to be made, which will have to be verified later.

Section 3: Overview of Inspection System

This section gives an overview of the inspection system (technique, procedure, equipment and personnel certification and training requirements) to be used. This section is provided largely for the benefit of the reviewer of the TJ.

Section 4: Analysis of Influential Parameters

Analysis of the influential parameters and identification of the essential parameters is a crucial exercise that helps ensure that all important parameters have been considered. These parameters define the limits for which the capability described in the TJ is valid and should be based upon the identified input parameters. The value of the essential parameters including tolerances and/or allowable range should be identified.

It is recommended that the essential parameters should be divided into two groups. Firstly, those designated as 'Set 1 essential parameters' in reference [6], which particularly affect the outcome of the inspection and which require detailed treatment in the TJ, and secondly, those designated 'Set 2 essential parameters', which affect the outcome of the inspection, but only if they vary significantly from their expected or designated values. The latter require less detailed treatment in the TJ and may even, in some cases, be ignored altogether once they have been identified.

Section 4 should list, explain the influence of, and give references to where in the TJ the Set 1 parameters are considered in detail. It is often convenient to present this information in the form of a table. The Set 2 parameters can often be addressed by a short comment within such a table itself. If the Set 2 parameters are numerous their analysis can be relegated to an appendix for the sake of clarity.

Section 5: Physical Reasoning (Qualitative Assessment)

This section contains a qualitative assessment and justification, using physical reasoning, of the essential parameters identified in Section 4. The content of the section will depend on the particular inspection and the information available but the intent should be to explain the inspection approach as comprehensively as possible, in terms of the component and defect details and the required performance. As a minimum, the specific procedure/equipment identified for use in the inspection must be addressed. However, the more generic the arguments made, the easier it will be to justify subsequent changes to equipment/procedures without the need for re-qualification.

The Physical Reasoning section of the TJ may include discussion of the Worst Case Defects (those that by virtue of their size, location, orientation and morphology present the most difficult challenge to the inspection procedure being qualified), and may often provide sufficient information to begin the process of designing and procuring test specimens for open and blind trials. Since this is often a lengthy process, it is acceptable to submit the Physical Reasoning part of the TJ to the Qualification Body early, before the whole TJ has been completed. Where a more quantitative treatment of worst case defects is necessary, this should be provided in Section 6.

Section 6: Prediction by Modelling (Quantitative Assessment)

This section explains and presents predictions from theoretical modelling that help show that the required inspection performance for detection, sizing, and characterization can be achieved. This can include the extrapolation or interpolation of results obtained from experimental evidence (Section 7) and parametric studies (Section 8) to the case in question.

It is highly desirable that validated models should be used (although in some circumstances unvalidated models may be used [7]), that any assumptions, limitations and simplifications made are understood and that the model is used within the bounds of its applicability. Guidance on the use of modelling is given in ENIQ Recommended Practice 6 [7].

This section should also be used to provide a quantitative assessment of the worst case defects where this is appropriate.

Section 7: Experimental Evidence

This section presents evidence from experimental studies on full-scale or simplified test specimens, results from previous qualifications, experimental results from previous reports or the published literature, results from round-robin trials and field experience.

Care must be taken to ensure that the evidence presented is relevant to the case in hand and in particular that any inferences or conclusions drawn from pre-existing studies or qualifications are valid. Any references cited should be available to the Qualification Body or the relevant information should be summarised and included in the TJ.

Evidence of compliance with established practices, including those incorporated into relevant established national and international standards, can also be included in this section.

Section 8: Parametric Studies

Parametric studies should be presented in this section. These are additional investigations of parameters identified in Section 4, which are performed to supplement the evidence presented in Sections 6 and 7. Such investigations will typically use simplified test pieces and concentrate on the influence of a single parameter, to investigate aspects of the inspection that cannot be easily or reliably modelled.

The studies cited can be previous work, or work carried out specifically for the component in question.

Section 9: Equipment, Data Analysis and Personnel Requirements

This section presents evidence to show how the selected inspection equipment (hardware and software) is able to provide the technical capabilities necessary for achieving the inspection aims. It should show that the values of influential parameters specified in the inspection procedure are consistent with the analysis of influential parameters performed in Sections 4 to 8. It should also explain how system acceptance tests, routine calibration tests and periodic system checks provide assurance that the performance demonstrated in qualification can be achieved and maintained at point of use.

This section should also include a justification of the evaluation/analysis scheme used for data interpretation.

If an analysis of the measurement uncertainty has been performed, the results should be presented in this section.

Personnel requirements, in terms of specified experience, training and certification, should be justified in the light of the inspection requirements, including rigour, importance and novelty.

Section 10: Review of Evidence Presented

This is an important section, which should be present in all TJs. It summarises the preceding sections to present the performance that the inspection system can achieve, (in terms of defect detection, size measurement and characterization capability) taking into account the identified essential parameters. It also justifies, by reference to the input group of influential parameters and the relevant preceding sections, that the personnel training and any qualification arrangements proposed are capable of achieving the inspection objectives. It also identifies any aspects of the inspection that cannot be fully justified and which may therefore require additional empirical qualification by practical trial.

If the evidence shows that it is not possible to meet all the inspection objectives then this should be mentioned clearly in this section.

Section 11: Input on Test Pieces for Experimental Trials

This section provides advice to the Qualification Body/Utility, based upon the preceding sections, on the design (geometry, material structure, access conditions, worst case defects etc.) of the test pieces to be used during any necessary practical trials. As test piece procurement can be a lengthy process, if early design of test pieces is needed, the input can be based on physical reasoning, which is usually available at the start of the TJ compilation process, and provided to the Qualification Body in draft form.

Where test piece trials are required, it is self-evident that this section is extremely important in order to guarantee that the test piece trials complement the other evidence presented in the TJ and vice-versa. The need for blind trials for personnel qualification is an issue which, in many practical cases, will be the result of an agreement between the utility and the regulatory body. If this is the case then this should be taken into account when writing the TJ.

Section 12: Conclusions and Recommendations

This should draw together all conclusions from the preceding sections. It makes a statement of capability for the inspection procedure being justified that states how and to what extent, the inspection is capable of meeting the inspection objectives, as specified by the Input Group essential parameters. Any significant weaknesses of the inspection or of the TJ should be declared and any recommendations as to how these weaknesses might be addressed, for example by additional limited open trials, can be given for consideration by the Qualification Body.

Section 13: References

A comprehensive and detailed list of all the references cited in the TJ should be provided.

The evidence cited in the TJ may be either pre-existing evidence or new evidence. Pre-existing evidence may come from the published literature, internal reports of earlier studies or other similar sources. New evidence is generated specifically for the case being considered, by carrying out new experimental studies, runs of theoretical modelling codes, etc. New evidence is usually needed when the pre-existing evidence is inadequate or not sufficiently relevant. Evidence should be of the quality necessary to support the case being made and open to scrutiny and verification.

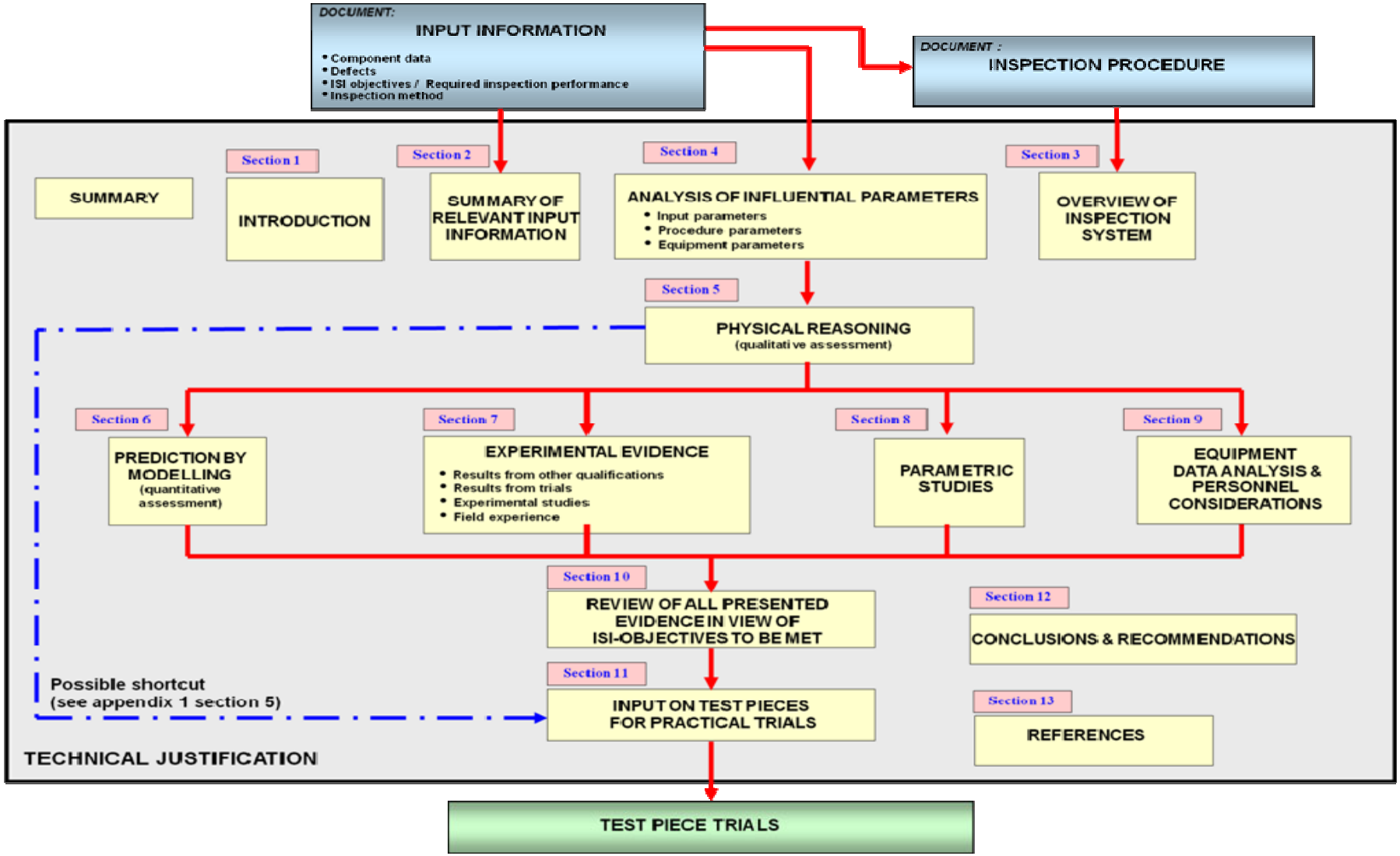

Figure 1: Recommended TJ Sections and Relationship to Other Elements of the Qualification Process

2.4.2 Contents of the TJ as a function of the specific application

In Section 2.3, the different types of TJ were outlined: e.g. to justify a procedure, to justify equipment changes and to extend an existing qualification to new component geometries, etc. The question therefore arises as to what evidence will be needed in each of the different types of TJ. Unfortunately it is not practical to give general guidance. Each case will be different and the precise content of the TJ will need to be decided on a case-by-case basis, depending on such factors as the extent of available evidence and the desired level of the TJ (see Section 2.5).

It should be assumed however, that all TJs are likely to require at least the following sections:

- Overview of the input information:
- Overview of the inspection system to be used
- Analysis of the influential parameters
- Physical reasoning (qualitative assessment)
- Review of all presented evidence considering the inspection objectives to be met
- Input on test piece trials (where they are required).

These sections should be supplemented with other sections as necessary.

Note that in some countries it is foreseen that for particular situations, only qualification of the inspection equipment will be required. For these particular cases, the TJs will mainly focus on the equipment related issues.

2.5 Level of a TJ

The ENIQ European Methodology Document [1] recognises that the level of an inspection qualification can vary from case to case, depending on factors such as the safety relevance of the component and the structural significance of the defects. The level required is a matter to be agreed between the different parties involved. This issue is discussed in detail in ENIQ Recommended Practice 8 [8].

Similar considerations also apply to the TJ, since this is a key part of the qualification process. It is not possible to specify in advance a detailed list of all issues which must be covered in all TJs. Rather the issues covered will vary from case to case, depending on factors such as:

- The safety relevance of the component and the structural significance of the defects.

  It will generally be desirable to generate TJs of the highest level in cases where the component and the inspection have the greatest safety relevance. TJs of lower level will generally be adequate in cases where the consequences of an inspection are purely economic or are of minor safety significance.

- The difficulty or novelty of the inspection.

  A typical inspection will normally involve many aspects which are completely routine and straightforward, and perhaps just a few aspects which are novel or present a particular challenge. For example, a proposed ultrasonic inspection of a ferritic butt weld may involve standard equipment and many standard defect types, but may present a particular challenge for certain defects because of access restrictions. In such circumstances it is perfectly acceptable for the TJ to concentrate on the novel or difficult aspects of the inspection, with little or no discussion of the routine aspects. Indeed, such selectivity is to be encouraged, so that both the authors of the TJ and the assessor in the Qualification Body can focus their attention on the most important aspects of the inspection.

- The extent of available evidence

  In some cases, there may be little or no relevant evidence available about some aspect of an inspection, so that a convincing case about this aspect cannot be made in the TJ. In such cases, the limited available evidence (if any) should still be cited in the TJ, but the limitations of the evidence should be clearly acknowledged. A failure to provide convincing evidence in the TJ about all aspects of an inspection should not lead to abandonment of the TJ or the overall qualification process. Rather the TJ should still be submitted to the Qualification Body, who can then decide on the appropriate course of action, for example specifying additional open or blind trials to address the deficient aspects of the TJ.

  In some cases the Qualification Body may decide that no special action is needed to address the deficient aspects, because in their judgement these aspects are not sufficiently important to the overall case of justifying inspection capability. In such cases a qualification certificate would still be issued by the Qualification Body, possibly with some caveats recognising the limitations of the TJ. Although issuing qualification certificates with such caveats is clearly undesirable, it will still normally be preferable, if the only other practicable course of action is to abandon the qualification altogether. It will generally be better to qualify an inspection in most but not all of its aspects, than not to qualify it at all.

- The extent of available data about the actual condition of the plant

  In some cases, plant data needed for the TJ may not be available. An example is the macrostructure of an austenitic weld, which has a significant effect on ultrasound propagation and is therefore an important input into the TJ of an ultrasonic inspection of such a weld. In such cases assumptions will have to be made in the TJ about the likely plant data. If possible evidence should be cited to demonstrate robustness of the TJ to uncertainties in such parameters, i.e. a sensitivity analysis should be included. However, it must be recognised that a TJ for which data on some aspect of the plant is unknown is likely to be less rigorous than one where full information is available. This difficulty is not peculiar to TJs: it will also be a problem when attempting to qualify using open or blind trials.

Summarising, the essential requirement in all cases is that the TJ gives a sufficient level of detail to be acceptable to the Qualification Body. It is important that the TJ focuses on those issues of most concern for the particular inspection being considered, without being padded out with extensive analysis of minor issues of little consequence. Such analysis of minor issues merely leads to an excessively long TJ without adding to its technical value. A considerable element of judgement will generally be involved in identifying the most significant issues to be addressed. It is therefore important that both

the organisation preparing the TJ and the Qualification Body can call upon NDT experts able to make such judgement.

2.6 Balance between TJ and test piece trials

An important role of the TJ is to minimise the number of test piece trials required and hence minimise the cost of qualification. In doing this it will sometimes be necessary to strike a balance between reducing cost and maintaining adequate rigour and it is important to make sure that the theoretical and practical evidence will together provide sufficient evidence to satisfy the Qualification Body. The main factors affecting the balance between TJ and test piece trials are:

- The safety relevance of the component

  If the safety relevance of the component and the structural significance of the defects are very high, then the TJ will have to be very rigorous in order to be able to avoid/minimise test piece trials. If, however, the safety relevance is not very high or if economic aspects are predominant, then the weight of the TJ could increase significantly. Note that the safety relevance of the component will also determine the qualification level required.

- Extent of available evidence

  If the extent of available evidence is limited, the importance of test piece trials will increase. If, on the other hand, a lot of evidence is available then the relative weight of test piece trials can decrease. It is important that the relevance of the available evidence is always carefully checked, as the circumstances in which the evidence was gained may not be the same as those under which the actual qualification is performed.

- Inspection technique specific issues

  For a given inspection technique, the specific characteristics of the component may pose problems for compiling a TJ. For example, in the case of ultrasonic inspection there may be problems due to the material structure or the surface conditions such as the exact characteristics of the weld root or weld crown.

  These are strongly influenced by the precise way in which components are fabricated, which means that any evidence supporting inspection performance arising from previous inspection of real or test components is often very specific to the method used to fabricate those components. This tends to limit the amount of directly relevant evidence available, although it may be possible to extrapolate performance based on results from components made in a similar but not identical way to the actual case. Where this is done, it will be necessary to justify any assumptions and limitations in the TJ.

3 References

1. European Methodology for Qualification of Non-Destructive Testing, Issue 3, ENIQ Report 31, EUR 22906 EN, published by the European Commission, Brussels-Luxembourg, 2007.
2. 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.
3. 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.
4. ENIQ Glossary, Issue 2, ENIQ Report 7, EUR 18102 EN, published by the European Commission, Brussels-Luxembourg, 1999.
5. ENIQ Recommended Practice 5, Issue 2, under preparation.
6. ENIQ Recommended Practice 1: Influential/essential parameters, Issue 2, ENIQ Report 24, EUR 21751 EN, published by the European Commission, Brussels-Luxembourg, 2005.
7. ENIQ Recommended Practice 6: The use of modelling in inspection qualification, Issue 1 ENIQ Report 15, EUR 19017 EN, published by the European Commission, Brussels-Luxembourg, 1999.
8. ENIQ Recommended Practice 8: Qualification levels and approaches, Issue 1, ENIQ Report 25, EUR 21761 EN, published by the European Commission, Brussels-Luxembourg, 2005.

APPENDIX 1 – Details of the content of the sections of a TJ

This appendix gives further details of the possible contents of the various sections of a TJ, using the recommended list of contents given in Section 2.4.1.

It should be emphasised that this Appendix is intended primarily as a check list of the kind of information that might be included in each section of the TJ. It is not intended to be a prescriptive list. The amount of information to be included in any specific TJ will vary from case to case, depending on such factors as the safety consequences of the inspection, the role of the TJ in the overall qualification process, the amount of evidence available, the state of knowledge about the component and so on. Section 2.4.2 provides more information on the content of the TJ as a function of its purpose.

1. Introduction

This should contain the following information:

- Components covered by the TJ
- Defects to be considered
- Inspection methods to be addressed
- The purpose and scope of the TJ
- Description of the layout of the TJ.

2. Summary of Relevant Input Information

It is highly desirable that before commencing work on the TJ, all relevant input information as discussed below is available.

Input information includes all aspects of the components and defects that can influence the outcome of the inspection performed, including, for example: materials, geometry, inspection volumes, access restrictions, defect descriptions and required performance levels for detection, sizing, characterisation and false call rates. If the information is not available, assumptions may need to be made to permit progress. It is essential that these be agreed between all interested parties at the outset. The need to amend an assumption which is challenged later may undermine the whole qualification.

2.1 Components

The information which may be needed regarding the components is listed below, although it is emphasised that all the items on the list below may not be needed or may not be available. In the latter case, the fact should be acknowledged in the TJ. The component information used in the TJ should be included either directly, or by reference.

- Component drawings showing details of the geometry and all dimensions
- Specifications for all the materials in the component including parent materials, weld materials and buttering materials
- Welding and buttering procedures used to fabricate the components
- Details of any weld repairs carried out through the history of the component
- Details of any known mismatch between components

- Component surface finish including both small scale roughness and longer scale undulations
- Details of weld caps and roots where relevant to the inspection i.e. where caps may need to be scanned or defects located near the root
- Any access restrictions that would limit the application of particular inspection techniques
- Any time constraints for inspection set by radiation levels or other environmental factors.

2.2 Defects

For the defects, the following information may be needed depending on the inspection method to be used:

- Defect types which must be detected
- Defect sizes to be detected
- Defect location, in particular, the relationship of defect position to features of welds such as roots, heat affected zones, caps or surfaces, cladding interfaces and other defects
- Defect orientation ranges in terms of tilt, skew and alignment relative to boundaries, surfaces and welds
- Defect morphology (roughness, gape etc).

2.3 Inspection objectives – Inspection performance

Depending on the purpose of the inspection, different parameters defining performance may be of importance. The ones that are relevant to the particular problem should be included in the TJ. The following list indicates some of the parameters that may be specified:

- Inspection area/volume
- Detection requirements
- False call rate
- Sizing accuracy in depth and/or length
- Defect characterization requirements
- Detection of remaining ligaments and measurement accuracy
- Acceptance and rejection criteria.

3. Overview of Inspection System

Depending upon the specific purpose of the TJ this section will contain an overview of the inspection procedure and/or the inspection equipment which will be used.

This section could also contain an overview of the personnel requirements, e.g. background experience, certification level, job specific training and qualification arrangements.

Examples of important characteristics of the inspection system for different inspection methods are given below. These lists are not intended to be exhaustive.

Ultrasonics

- Probe beam angles
- Probe types - shear or compression, single or twin crystal, focused or unfocused, focal distance etc.
- Inspection Method: Pulse-echo, TOFD, Phased Array …
- Probe frequencies
- Scanning extent and pattern
- Manipulator and control system
- Scanning and recording sensitivity
- Sizing method
- Instrumentation hardware and software for data acquisition and data analysis.

Eddy Currents

- Coil type - bobbin, pancake etc.
- Coil orientation relative to the component surface
- Inspection method, absolute, driver – pickup, x coil etc.
- Frequencies
- Scanning extent and pattern
- Scanning and recording sensitivity
- Type of inspection equipment for data acquisition and analysis.

Visual

- Inspection method - TV, remote optical, direct visual etc.
- Lighting level
- Recording medium
- Resolution.

In general, and especially when the inspection is complex or difficult or when test pieces are not available, it is likely that parts of the TJ, (especially the review of input parameters, the influential parameter analysis and the physical reasoning sections), will be produced in advance of or in parallel with the procedure. This will usually be advantageous, as weaknesses in the inspection design will be detected at an early stage, allowing corrective action to be taken before the procedure is submitted for qualification.

4. Analysis of Influential Parameters

4.1 Analysis of influential parameters

There are many parameters that can influence the outcome of an inspection and ENIQ Recommended Practice 1 addresses this subject. To aid identification of influential parameters they have been subdivided into two groups:

- The Input Group contains the parameters which define the inspection situation. These include relevant details of the component, defects and required inspection performance

- The NDT System Group contains all the parameters of the procedure and the inspection equipment. Ideally, these are chosen on the basis of the input parameters to ensure that the inspection has the required performance. However, previous practice or the requirements of codes and standards may also be the basis on which the inspection parameters were chosen.

The NDT system group parameters can be subdivided into Set 1 and Set 2 essential parameters. The Set 1 essential parameters are those which particularly affect the outcome of the inspection and these should be considered in detail in the text of the TJ. The Set 2 essential parameters are those which affect the outcome only if they differ by a substantial margin from the values specified in the inspection procedure. The Set 2 essential parameters do not have to be addressed at length in the TJ. However, it will usually be necessary to perform some analysis to determine which set any particular parameter belongs to and it is strongly recommended that they are included, perhaps with a demonstration that they would have to exceed their stipulated tolerance before they jeopardised the inspection. Regular calibration may then be sufficient to demonstrate that there is no problem and the TJ should indicate where this is the case. For the sake of clarity it is advantageous to present any treatment of the Set 2 essential parameters in an appendix to the TJ.

The Set 2 essential parameters in particular may include equipment parameters that are selected on the basis of previous experience or practice, including applicable codes and standards, and often demonstrated in the course of development work and empirical trials. Where this is the case, the parameters should be noted as being selected on the basis of experience and/or practical trials and where applicable a range of acceptable values should be given along with the specific value(s) for the parameter given by the inspection procedure.

Inspection procedures often identify a single value for a Set 2 essential parameter that allows effective inspection, without explicitly exploring the sensitivity of the inspection to changes in that value. If the TJ presents only this value it may be impossible to make subsequent changes to the procedure without invalidating the qualification. By listing separately the acceptable range of parameter values and the specific values defined by the procedure it is possible to give greater flexibility for making future procedural changes, provided of course that the range of acceptable values claimed is justified in the TJ and accepted by the Qualification Body.

Where it is not planned to define a value for a particular essential parameter in the TJ, this should generally be stated together with the reason for this: e.g. no information on the value of the parameter is available or there is no way currently known to predict the effect of varying the parameter.

Clearly, the essential parameters of the inspection must be specified as soon as possible, since they are the basis of the evidence to be provided in the sections of the TJ discussed hereafter.

5. Physical Reasoning (Qualitative Assessment)

The information presented in this section should justify the choice of inspection parameters in qualitative terms. It should explain firstly, by reference to the component and defect details, why the particular inspection method was chosen. In cases where ultrasonic inspection is the chosen method, this might, for example, include the need to detect embedded defects or ones on the far surface of a component and the need to provide through-thickness size information.

Having explained the choice of the method of inspection, the form in which the method is implemented should be justified. For example in ultrasonic inspection, the choice of technique (pulse-echo, TOFD etc) and of beam angles and allowed

tolerances in beam angle, needed to achieve the required coverage for detection, sizing and characterisation, should be explained. Scanned areas should be explained in terms of the expected defect positions and orientations. The probe types and wave modes used must be suitable for the components on which they are to be deployed, for example taking into account the need to work through austenitic structures or to detect near surface defects and so on. The sizing method should be related to the sizing accuracy required.

Although plausible explanations can be given for the choice of inspection parameters in this section, it should be remembered that the evidence appears in the sections that follow. For example, there are complex interactions between beam angles, sensitivity settings and defect morphology and the choices made can often only be justified properly using the quantitative approach in the sections of the TJ which follow the physical reasoning one.

What is included in the Physical Reasoning Section will depend on the particular inspection and the information available but the intent should be to explain the inspection approach as comprehensively as possible in terms of the component and defect details and the required performance.

The information in the Physical Reasoning section of the TJ may be sufficient to begin the process of designing and procuring test specimens for open and blind trials. Since this is often a time-consuming process, it is acceptable to submit the Physical Reasoning part of the TJ to the Qualification Body early, before the whole TJ has been completed.

6. Prediction by Modelling (Quantitative Assessment)

This section contains any results of modelling calculations performed in order to justify the choice of inspection parameters. This may include predicting defect responses by taking into account defect characteristics and position and orientation effects. Modelling can also be used to predict coverage and (for ultrasonics) beam paths in components of complex geometry. Recommended Practice 6 [7] gives further information on the selection and use of mathematical models.

Models which have been fully validated against experiment are preferred, and where necessary reference should be made to the validation work which supports them. Care should be taken when using models which have not been fully validated against experiment: such models should only be used in a supporting role, to support experimental results, or should be explicitly validated for the cases of interest as part of the TJ itself. Limitations of models used should be clearly indicated. Care should also be taken that all models are only used within the parameter ranges for which they are valid.

For ultrasonic inspections modelling calculations may be used for the following purposes:

- To show which are the most difficult defects to detect from amongst those in the defect specification. This can be done from consideration of the angles of incidence and access to the defects in the defect specification, for all the different probes used
- To show that the most difficult defects will generate responses above the recording level with at least one of the probes used and to demonstrate the margin of detection for the probes which detect them. If it can be shown that there is detection by multiple probes, even of the worst case defects, it provides evidence that the inspection procedure offers diversity, leading to a higher detection probability
- To interpolate between cases covered by experimental data (see Section 7), in order to provide a fuller assurance of capability over the ranges of variability of such essential parameters as defect orientation, location and size
- To show that the above situation applies to all the components covered by the TJ notwithstanding differences in geometry and dimensions
- To show that diffracted edge signals can be observed at the chosen sensitivity levels, thereby permitting defect size measurement using methods that rely on the observation of such signals
- To evaluate the effect of the surface conditions, such as presence of weld root and weld crown, etc
- To analyse the influence of material structure, as for example in austenitic welds and clad components or when different materials are joined.

It should be noted for example, that validated models which predict the ultrasonic response from defects are less widely available when defects are embedded in inhomogeneous anisotropic structures such as austenitic welds or when beams must traverse such materials to reach the defects. The demonstration of performance for such cases may therefore rest more on test piece data obtained from parametric studies than for materials where effective models are available. However, physical reasoning can still be used to highlight the defects which are likely to be most difficult to detect, for example because they exhibit the maximum misorientation to the beams used.

7. Experimental Evidence

This section of the TJ should contain results for relevant pieces of experimental work, which support, for example, the inspection procedure. The work might include the following:

- Results from practical trials associated with previous qualifications
- Results from round robin trials such as the PISC exercises
- Results from experimental studies performed in the laboratory, using either fully representative or simplified test specimens. These studies may already exist (e.g. in reports or published papers) or may be conducted explicitly as part of the specific qualification being considered. The work may also involve full-scale test pieces, including those developed for open trials, should the progress of the qualification provide such an opportunity
- Field experience results.

It is important that any results from pre-existing studies, other qualification exercises or previously conducted round robin trials in the TJ are shown to be relevant. This will involve citing the component, defect and inspection details for the experimental work

to show they are sufficiently similar to those in the present case. It is possible that only part of an experimental study is relevant, for example if just a few of the probes used in an ultrasonic inspection correspond to those used in the actual procedure. In such cases, the experimental work can be used to provide support for a part of the procedure, by presenting the relevant results from the experimental study.

If the details of the components, defects and inspections for the experimental work in question are similar but different to the ones for the components which form the subject of the TJ, it may be possible to use modelling or parametric studies to establish the relevance of the results.

Experimental laboratory studies may also be performed specifically for the qualification being considered. Such studies are distinct from the open or blind trials, since they are performed in-house, in order to provide further evidence for the TJ. Open and blind trials, on the other hand, are supervised by the Qualification Body, usually use test blocks designed by the Qualification Body, and are generally conducted after completion of the TJ. When performing such studies, attention may need to be given to specific characteristics of the component such as material structure, surface condition and access restrictions.

In the case of ultrasonic inspections of austenitic welds or clad components, the material structure plays an important role and may give problems that are not present for ferritic materials. These stem from the influence of the metallurgical structure on inspection performance and the structure, in turn, is influenced by the precise way in which components are fabricated. This means that any evidence supporting inspection performance arising from previous inspection of real or test components may be very specific to the method used to fabricate those components. This tends to limit the availability of directly relevant evidence. Care should be taken when citing experimental results from austenitic structures, to ensure that the macrostructures of the materials used in the experiments are relevant to the qualification being considered.

In the absence of existing information on the influence of the material structure it may be useful to do measurements on specifically designed representative test pieces. When such experiments are conducted specifically for the qualification, it is desirable that the test specimens are made using the same welding procedures as used on the actual component. This will provide maximum assurance that the macrostructures in the specimens replicate those on the plant.

The exact geometry of the weld root and weld crown can also have a profound influence on the inspection performance and care must be taken to ensure that any evidence from previous inspections or studies is genuinely relevant and not influenced by differences in preparation such as weld crown dressing to allow better access for scanning.

Other parameters which might need to be investigated include the following:

- Component surface roughness and undulations
- Defect roughness
- Compressive stress on defects
- Comparison of responses from real and artificial defects
- Component mismatch
- Counterbore position and angle.

Note that parametric studies, as discussed in the following section, can be very useful when addressing these parameters.

8. Parametric Studies

Parametric studies can be considered as a special type of experimental evidence. They are mentioned separately because of the relative importance they may have. Their purpose is to investigate the influence of parameters such as those listed above, preferably using small and simple test pieces, so that the magnitude of any effects on the inspection can be understood. Another consequence is that open or blind practical trials do not have to take specific account of the particular parameter because the effects of it can be built into the results. Parametric studies on defects produced by artificial methods can be particularly helpful in supporting the use of those defect types in open and blind trial test pieces. Any information which demonstrates the relationship between the responses from the artificial and real defects to the NDT method in use, is particularly valuable for this purpose.

Where relevant work has already been carried out and reported, it can simply be cited in the TJ. The TJ should then include:

- A reference to the work
- An explanation of why the work is relevant to the present case
- A description in the text of the TJ of what the reference shows regarding the effects of the particular parameter
- The impact of the parametric study on the theoretical case for the inspection
- The impact of the parametric study on test pieces for practical trials.

For parameters which have not been the subject of relevant studies elsewhere, for example where the influence of cladding and dissimilar metal welds has not been treated by modelling, or where additional supporting evidence is considered to be necessary, specific parametric measurements may be carried out and reported as part of the TJ. The information presented should include the following:

- Description of the parameter concerned
- Details of the test pieces used
- Description of the measurements made
- Analysis and discussion of the results of the measurements,
- The impact of the parametric study on the theoretical case for the inspection
- The impact of the results on the selection of test pieces for practical trials.

9. Equipment, Data Analysis and Personnel Requirements

9.1 Equipment

This section should contain the information which justifies the choices made when selecting the inspection equipment. By reference to the essential equipment parameters identified in Section 4, it should show that the equipment is fit for purpose and has the required capability. It should also justify the range/tolerance over which essential parameters can vary and the equipment remains qualified and provide information about calibration and system-check requirements.

Specifying equipment in terms of performance and capability, rather than by make and model, will make it easier to allow for the inevitable operational requirement to make changes to some parameters and also to allow for substitution of equipment in the event of breakdown or updating.

This section should also explain and justify how calibration tests and periodic equipment checks help to ensure that the level of system performance obtained during inspection validation will also be available when the inspection is applied to the actual component.

If the actual inspection conditions will be more extreme than can realistically be addressed in experimental trials (e.g. high radiation levels, extreme temperatures and restricted access), this section should explain how the selected equipment will remain effective under these conditions.

9.2 Data analysis

This section should contain the information which justifies the choices made for the software for representation and interpretation of the acquired inspection data. The evaluation/analysis scheme used for data interpretation should also be justified for detection and /or sizing as appropriate.

The data analysis scheme used to judge whether the indications found are due to defects is an extremely important part of the inspection procedure. All of the decision steps related to the combination and interpretation of the results of the different techniques that allow the analyst to arrive at the final result, should be written down in a clear, logical and traceable manner in the procedure and the most important decision steps should be identified and justified in the TJ.

Examples of decision steps which may need to be justified in the TJ, are:

- The criteria used to distinguish indications due to the geometry of the component from those due to real defects
- The reporting threshold above which indications have to be reported (if not considered elsewhere in the TJ)
- The way the results of different techniques are combined in order to decide if an indication is due to a defect or not
- The criteria used to characterise defects, for example to determine whether they are surface-breaking or embedded, volumetric or planar
- The criteria and methods used to determine which signals should be used to measure the defect size and how the size of the identified defects is to be measured.

This section should state and justify the defect detection capability of the techniques to be applied, either in terms of the size of the minimum defect that can be reliably detected or in terms of probability of detection and/or false call rates. Where defect sizing is an inspection requirement, the expected sizing performance, including measurement accuracy and reliability requirements should also be addressed and any performance figures presented should include sizing tolerances and confidence levels. The methodology and calculations by means of which these figures are derived should also be presented or referenced.

9.3 Review of personnel requirements

Personnel qualification is often done on the basis of a basic qualification in line with a national certification scheme, to which is added any job-specific training considered necessary to enhance the basic skills of the inspection personnel, and/or any practical qualification exercises considered necessary to demonstrate that the personnel are capable of adequately applying those skills to the inspection being undertaken. Generally, the more difficult the inspection, the greater the novelty of the techniques to be used and the more serious the consequence of poor inspection, the more rigorous are the personnel qualification requirements and the greater the level and amount of training specified.

This section of the TJ should discuss the personnel qualification requirements and any special training provision, in the light of the information relating to the difficulty and novelty of the inspection presented in the rest of the TJ. It should then present the evidence and arguments that demonstrate that the proposed scheme will be adequate. Where inspections are performed by teams made up of personnel with different roles (e.g. scanner operator, data collector and data analyst), the requirements and responsibilities of each role should be explained.

In those countries where national inspection qualification schemes require that only qualified inspection personnel should pronounce on the findings of an inspection, the allocation of responsibility for reporting should be clearly stated.

10. Review of Evidence Presented

This section of the TJ should pull together all relevant information from the preceding sections and make an overall statement for the capability of the inspection system. This should indicate the performance to be expected, based on the evidence presented, for the defects listed in the defect specification as measured against the required performance for detection, size measurement and false calls. Any shortfalls against the required performance in the input information should be clearly stated.

Furthermore, in this section a review should be made of all the evidence given in the previous sections in view of the essential parameters identified for the NDT System group and for the input group. Issues that could be treated are:

- Extent to which the choice of all identified essential parameters has been justified
- Further actions required to obtain missing information
- Identification of the parameters which need not be considered further as a result of the presented evidence
- Identification of any additional essential parameters that need to be considered or investigated during the qualification process
- Identification of those essential parameters which should be considered during the test piece trials.

The statement should also indicate aspects of the inspection where insufficient theoretical or experimental evidence exists.

This section should also contain any comments on the personnel qualification requirements which emerge from the analysis of procedure capability in the TJ. If personnel requirements are included these can be commented on directly. If they are not, comments should be made on the desirable features of any requirements to be incorporated later.

11. Input on Test Pieces for Practical Trials

This section of the TJ should contain advice about the test pieces which should be used for practical trials in the light of the evidence presented in earlier sections. If the concept of limit/worst case conditions (related to the specific inspection situation considered) is used, the specific cases selected should be described and justified in this section.

It might include the following depending on the component and evidence available:

Open Trials

- Advice on the geometry and dimensions of test pieces bearing in mind the need for the practical trial results to be relevant to the components included in the TJ
- Advice on the defects that test pieces should contain including type, position and orientation. These could take into account the defect specification and the defects identified as most difficult to detect and size as discussed in Sections 5 and 6
- Advice on the methods which should be used to incorporate defects in test pieces should be made bearing in mind the parametric studies discussed in Section 8
- Advice on the welding procedures to be used for test pieces
- Advice on whether test pieces representing clad ferritic components need to be clad themselves, bearing in mind the parametric studies discussed in Section 8.

Blind Trials

Advice on the test pieces to be used for blind trials might be included here based on the information in the preceding sections of the TJ. The advice should be aimed at ensuring that the test pieces represent any situations of particular difficulty so far as application of the procedure is concerned. These might include, for example, problems of defect detection or size measurement in areas where signal to noise ratios are poor.

The TJ should also address access or environmental restrictions, as it is important that problems which affect the real inspection are reproduced so far as is possible during the open or blind trials. This section of the TJ should therefore highlight factors which should be borne in mind when open or blind trials are being planned. These might include, amongst others, the following:

- Time constraints arising from radiation, temperature or noise levels
- The need to work in inaccessible or uncomfortable positions
- The requirements for minimum illumination levels

- The need and feasibility of simulating distracting influences such as temperature or noise in the trials
- Lack of access for scanning or single side inspection etc.

12. Conclusions and Recommendations

This section should list all major conclusions of the TJ. This should include a clear statement of any limitations in performance identified when compared to the requirements stated in the input information. It should also list the recommendations emerging from the TJ for issues such as test piece design, personnel qualification requirements or equipment design.

13. References

All references cited in the text should be listed. Only references that are or can be made available to the Qualification Body should be included.

APPENDIX 2 – Overview of published ENIQ Recommended Practices

RP1	Influential/essential parameters, EUR 21751 EN
	ENIQ Recommended Practice 1 should assist those involved in inspection qualification in how to use and implement the concept of influential/essential parameters in agreement with the spirit of the European methodology. This version of RP 1 – Issue 2 – builds upon the experience gained in the use of Issue 1 since it was published in 1998. The main objectives of this Recommended Practice are: - to explain the concept of influential/essential parameters - to indicate how the concept can be used in inspection qualification according to the European methodology - to give advice concerning the classification of influential parameters - to give examples of parameters which can be influential as a function of the specific inspection to be qualified for two cases: an ultrasonic inspection of welds and an eddy current inspection of steam generator tubes.
RP2	Strategy and recommended contents for technical justifications, EUR 24111 EN
	This ENIQ Recommended Practice 2, describing the purpose of TJs and defining a list of recommended contents for writing them, is a combination of two previous recommended practices, RP2 and RP3 which separately dealt with the issues of TJ contents and TJ strategy. It should assist those producing TJs to identify the role of the TJ and the material that might be included. It should also assist in producing TJs in a uniform format throughout Europe.
RP3	Merged with RP2
RP4	Recommended contents for the qualification dossier, EUR 18685 EN
	This RP should assist those doing qualifications to identify the material which might be included in the qualification dossier, which is defined as an assembly of all the information relevant to the definition and execution of the qualification. It should also assist in producing qualification dossiers in a uniform format throughout Europe, an essential element in providing a general framework for a scheme of recognition of qualifications performed in the EU. Note that the concept of dossier is not that of a single document or report but rather that of a file in which key documents of the qualification are inserted.

RP5	Guidelines for the design of test pieces and conduct of open trials, EUR 18686 EN
	The purpose of RP5 is to provide guidelines for the design of test pieces and the conduct of test piece trials, once it is has been decided (for example, as a result of the analysis done in the technical justification) that they are required. It refers especially to those test piece trials (open or blind) that are supervised by the qualification body.
RP6	The use of modelling in inspection qualification, EUR 19017 EN
	This RP deals with the use of mathematical modelling in inspection qualification. Mathematical models have been developed by several organisations for various inspection situations and, where applicable, can provide valuable evidence on inspection capability for inclusion in a technical justification. Authors of technical justifications may therefore be considering the use of models. This RP provides advice on: - the types and range of mathematical models which are available - how the models can be used to generate evidence for a technical justification - important considerations and constraints in using models.
RP7	Recommended general requirements for a body operating qualification of non-destructive tests, EUR 20395 EN
	The document provides guidance on the minimum criteria that a body operating qualification of non-destructive testing should follow if it is to be recognised as impartial, independent of operational pressures, competent and reliable. Three types of qualification body are considered within the RP: Type 1: A qualification body which is an independent third party organisation Type 2: A qualification body which is an independent part of the utility's organisation set up on a permanent or long-term basis Type 3: An ad hoc qualification body set up for a specific qualification. The RP is mainly intended to provide guidance on the requirements for qualification bodies of types 1 and 2. An ad hoc qualification body, type 3, being more temporary and inspection-specific in nature, will generally be established in a less formal way than qualification bodies of types 1 and 2. However, many parts of the RP should still provide useful guidance for setting up an ad hoc qualification body. The RP should assist those who want to establish a qualification body and those who have to audit the competence of a qualification body. It should also assist in providing a general framework for a scheme of recognition of qualifications performed in the European Union (EU).

RP8	Qualification levels and qualification approaches, EUR 21761 EN
	This RP is intended to provide guidance on the setting of Qualification Level and on determining the Qualification Approach based partly on this choice of level. The Qualification Level required reflects the assurance required that the inspection will attain its objectives in demonstrating structural integrity and may depend on e.g. the safety significance of the component and the role of the inspection in assuring structural integrity. In practice, qualification can be done with varying degrees of complexity and cost. The way such work is carried out is defined in this document as the "qualification approach", and needs to take into account both the structural integrity significance and the difficulty of each specific inspection. The qualification approach determines to what extent the various aspects of qualification, i.e. technical justification, open trials, blind trials etc., are included in a particular case.
RP9	Verification and validation of structural reliability models and associated software to be used in risk-informed in-service inspection programmes, EUR 22228 EN
	Structural Reliability Models (SRMs) are commonly used to evaluate failure probabilities in the development of Risk-Informed In-Service Inspection (RI-ISI) programmes. This report summarises the Verification and Validation (V&V) requirements that a Structural Reliability Model (SRM) and associated software should satisfy in order to be suitable for such purpose. These requirements are mainly based on the work performed within the NURBIM project.
RP10	Personnel qualification, EUR 24112 EN
	This RP is meant to assist those involved in the qualification of inspection personnel to meet the principal objective of personnel qualification, i.e. to ensure that those carrying out an inspection are appropriately trained, experienced and examined to ensure it is applied correctly and effectively. Detailed guidance on how to conduct personnel qualification, handle qualifications to be renewed, and defining the role and responsibilities of the parties involved in the personnel qualification process is provided.

RP11	Guidance on expert panels in RI-ISI, EUR 22234 EN
	The European Framework Document for Risk-Informed In-Service Inspection is intended to provide general guidelines to utilities on how to develop RI-ISI approaches and use or adapt already established approaches to the European nuclear environment, while taking account of utility-specific characteristics and national regulatory requirements. The Framework Document recommends the use of an expert panel to review the selection of safety-significant sites before the inspection programme is finalised. However, more detailed guidance regarding the responsibilities, composition and working procedures of an expert panel is not provided. This ENIQ recommended practice is meant to assist users of RI-ISI applications in how to form, prepare and facilitate an expert panel whose final goal is to take decisions concerning the inclusion or exclusion of sites from the risk-informed inspection programme. A recommended practice is a document produced by ENIQ to support the higher level Framework Document. Users are free to use these recommended practices at national level, as they see fit. The main objectives of this recommended practice are to give guidance on: Composition of the expert panel; Responsibilities of the expert panel; Planning and preparation of the expert panel; Conduct of the expert panel; Documentation of the expert panel.

This page is intentionally left blank.

European Commission

EUR 24111EN – Joint Research Centre – Institute for Energy
Title: ENIQ RECOMMENDED PRACTICE 2: STRATEGY AND RECOMMENDED CONTENTS FOR TECHNICAL JUSTIFICATIONS
Author: Ian Atkinson (KANDE International)
Editor: Thomas Seldis (DG-JRC-IE)
Luxembourg: Publications Office of the European Union
2010 – 40 pp. – 21 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1018-5593
ISBN 978-92-79-08425-6

Abstract
This ENIQ Recommended Practice 2, describing the purpose of TJs and defining a list of recommended contents for writing them, is a combination of two previous recommended practices, RP2 and RP3 which separately dealt with the issues of TJ contents and TJ strategy. It should assist those producing TJs to identify the role of the TJ and the material that might be included. It should also assist in producing TJs in a uniform format throughout Europe.

How to obtain EU publications

Our priced publications are available from EU Bookshop (http://bookshop.europa.eu), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

JRC
EUROPEAN COMMISSION

LD-NA-24111-EN-C

ISBN 978-92-79-08425-6

9 789279 084256

Publications Office