NUCLEAR POWER PLANT PRESSURE EQUIPMENT

In-service inspection with non-destructive testing methods

continued

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Authorisation

By virtue of the below acts and regulations, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Government Resolution (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Resolution (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Resolution (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Resolution (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Resolution (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or to those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account section 27 of the Government Resolution (395/1991), which prescribes that *for further safety enhancement, measures shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.*

If deviations are made from the requirements of a YVL guide, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the guide is achieved.

Translation. Original text in Finnish.

1 General

By virtue of the Nuclear Energy Act (990/1987) and as stipulated by section 117 of the Nuclear Energy Decree (161/88), the Finnish Radiation and Nuclear Safety Authority (STUK) sets the rules and regulations that apply to actions and procedures that are the licensee's responsibility in the assurance of the safety of pressure equipment in nuclear facilities; STUK also follows the realisation of these requirements.

This guide presents requirements for the planning, qualification, control and reporting of the in-service inspection of nuclear power plant pressure equipment. It applies to the pre-service and individual in-service inspections of Safety Class 1 and 2 components and other structures important for nuclear safety by non-destructive testing methods (NDT). Of in-service inspections, pre-service inspections are usually conducted prior to the commissioning of a nuclear power plant. Individual in-service inspections are usually conducted during outages.

The in-service inspection of registered pressure equipment is discussed in Guide YVL 3.0.

2 Definitions

The terms used in this guide are defined as follows:

Acceptance standards
refer to STUK-approved flaw indication acceptance standards, or to other documents containing threshold values generally valid for a specific type of component, or parts thereof, not considering the actual stresses present in the point in question.

Blind trial
is *a practical trial* conducted by *an inspection system* to be qualified, which is witnessed by *a qualification body* and in which an inspection technique is applied to a test piece and those applying the NDT have no specific and detailed knowledge of the number, size, orientation and position of defects which the test piece may contain.

Essential parameters
are those parameters among *the influential parameters*, which have a significant influence on the quality and outcome of a particular inspection. They include parameters of *input information, the inspection procedure* and of equipment.

Essential parameters covering a range
refer to *essential parameters* over whose whole range the effectiveness of the inspection has to be demonstrated.

Essential parameters to be fixed within a tolerance
are those *essential parameters* which have specific fixed values within a tolerance.

False call
is an erroneous reporting of a flaw indication from a part of a test object which is, in fact, free of defects.

Flaw indication
is evidence of a flaw that is detectable by NDT methods.

Geometrical indication
is *an indication* of the geometry or metallurgical structure of the inspection area that is detectable by NDT methods.

Indications
mean *flaw indications* and *geometrical indications*.

Influential parameters
mean those parameters, relevant for the particular inspection, which may influence the quality and outcome of the inspection.

Input information
is information (including *essential parameters* describing the component, material, defects, etc), which has to be made available prior to the start of the process of *inspection qualification*.

Inspection procedure
is a definition of how an inspection is implemented for a specific test situation. A written description specifying all *essential parameters* and setting out the precautions to be observed when applying an inspection technique, following an established standard, code or specification.

Inspection qualification
means the systematic assessment, by all those methods that are needed to provide reliable confirmation, of *an inspection system* to ensure it is capable of achieving the required performance under real inspection conditions.

Inspection reliability
is the degree to which *an inspection system* achieves its purpose regarding detection, characterisation, and sizing at an acceptable *false call* rate.

Inspection system
means all those elements of non-destructive testing that can influence the quality and outcome of an inspection, such as inspection equipment and their software, *inspection procedure* and personnel.

Modelling
denotes the use of mathematical models of NDT to predict quantitatively the outcome of tests as part of *technical justification.*

Open trial
is *a practical trial* conducted by *an inspection system* to be qualified and which is witnessed by *a qualification body* and in which the inspectors have been given advance knowledge of the defects of the test piece to be inspected.

Parametric studies
mean experimental laboratory studies to establish the separate influence of various *essential parameters*.

Pass/fall criteria
mean the criteria relating to the number of defects detected in test pieces, number of *false calls*, size and positional accuracy and so on reported in an *inspection qualification* which determine the success or failure of the NDT inspection.

Physical reasoning
is part of *the technical justification* containing a compilation of the detailed reasons for selection of a particular NDT approach expressed in qualitative terms.

Practical trials
refer to the assessment of NDT such that it is applied to test pieces containing defects.

Qualification body
is an independent expert body conducting, assessing and witnessing inspection qualification.

Qualification dossier
is an assembly of all the information relevant to the definition and execution of the inspection qualification. It includes information on defects, components to be inspected, NDT conditions, and *the inspection procedure*. It also includes *the qualification procedure* and the results of *the inspection qualification*.

Qualification certificate
is a document issued under the rules of *an inspection qualification system* indicating that adequate confidence is provided that *inspection procedures*, equipment and personnel or any combination of these are capable, for a specific test, of achieving the stated objective of the test.

Qualification level
is the reference level of reliability required of the inspection system to be qualified. The qualification level defined in the *input information* is dependent on the nuclear safety risk significance of the structure failure and

reduction in the probability of failure arising from inspection. Failure probability and its consequences contribute to nuclear safety risk.

Qualification procedure
is an orderly sequence of rules, which describe how a specific non-destructive test on a specific component is to be qualified.

Qualification system
denotes a system that includes procedures and administration for management of qualification.

Recording level
means the threshold at which indications shall be recorded in the inspection records.

Risk-informed in-service inspection (RI-ISI)
means a programme in which the choice of inspection areas in accordance with Guide YVL 3.8 is entirely based on the use of *risk-informed methods*.

Risk-informed methods
denote, when mentioned in conjunction with in-service inspection, the combining of the results of probabilistic safety analyses with assessment of the failure mechanisms of equipment and structures as well as of the secondary effects of failures. In the application of risk-informed methods to the drawing up and development of inspection programmes for nuclear power plant components and structures, the plant's nuclear safety can be improved and radiation doses arising from the inspection environment reduced by effectively focused inspections and optimised inspection intervals.

Technical justification
refers to a collection of all the necessary information which provides evidence that *the inspection system* can meet its stated objectives. Technical justification may, however, be used for a number of other purposes such as for example to justify the defects or test pieces to be used during test piece trials or to justify an upgrade in inspection equipment without the need to repeat the whole qualification.

Worst case defects
are those cases of defects, component geometry or other *essential parameters* that are likely to present the greatest challenges for detection and accurate sizing within the framework of the specific situation considered for *inspection qualification*, as defined in the *input information*, and considering also the specific *inspection system* used.

Terms relating to inspection qualification can also be found in the ENIQ Glossary [1], which is in English.

3 Requirements

Section 35 of the Nuclear Energy Decree (161/1988) stipulates that an applicant is to submit a Preliminary Safety Analysis Report to the Finnish Radiation and Nuclear Safety Authority together with the application for a construction licence. A description of the principles applied during in-service inspection shall be included. The description shall present the general principles for in-service inspection, indicating the prerequisites for reliable and sufficiently extensive in-service inspection.

In the design of nuclear power plants, the accessibility of components and structures shall be considered in accordance with the following YVL guides: YVL 3.0, YVL 3.1, YVL 3.3, YVL 5.3, YVL 5.4 and YVL 5.7; structural radiation safety, as presupposed by inspections, shall be in accordance with Guide YVL 7.18.

Section 36 of the Nuclear Energy Decree (161/1988) stipulates that an applicant shall submit an in-service inspection summary programme to the Finnish Radiation and Nuclear Safety Authority together with the application for an operating licence.

The in-service inspection basic requirements shall be according to ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice

Inspection of Nuclear Power Plant Components, Division 1, (ASME Code, Section XI) [2]. Deviations from the Code shall be justified and it shall be demonstrated that a corresponding level of safety and reliability can be achieved. Additional guidelines are given in the International Atomic Energy Agency's safety guide Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants [3] and in the handbook In-Service Inspection of Nuclear Power Plants [4].

In the drawing up of inspection programmes for Safety Class 1, 2, 3 and 4 piping and Class EYT (non-nuclear) piping as well as in the development of inspection programmes for operating plants, risk-informed methods shall be utilised to ascertain the inclusion in the inspection scope of those components posing the highest risk.

If the choice of components to be inspected is entirely based on risk-informed methods (risk-informed in-service inspection programme), systems in Safety Classes 1, 2, 3, 4 and EYT (non-nuclear) shall be analysed as entities. The risk-informed in-service inspection programme is dealt with in [5, 6, 7, 8, and 9]. When changing an operating plant's in-service inspection programme to a risk-informed inspection programme, the changes shall be made in entities such that a better safety is achieved than with the inspection programme in use.

The document European methodology for qualification [10], drawn up by the European Network for Inspection Qualification, shall be used as the minimum requirement level for qualification of inspection systems to be used in-service inspection, and it shall be complemented by recommended practices [11, 12, 13, 14, 15, 16, and 17].

4 In-service inspection

4.1 General

The scope and manner of the performance of in-service inspection is defined in the below documents:

- the summary programme
- the pre-service inspection plan
- individual in-service inspection plans.

The licensee shall keep all documents updated such that the programme and its procedures are always unambiguous. The edition of ASME Code, Section XI [2], as amended, on which the programme is based, shall be given.

4.2 Summary programme

The summary programme shall cover all Safety Class 1 and 2 as well as other components and structures considered important to nuclear safety (pressure vessels, piping, pumps, valves and their supports as well as reactor pressure vessel internals). The principles governing selection of the areas of inspection and the methods and frequency of inspection, and also reporting of the inspection results and the procedures for recording and evaluating flaw indications shall be presented in the programme from pre-service inspections of the nuclear power plant until the end of the plant's operating life.

If components and piping important to safety have areas subject to particularly high stress, or loads which can not be reliably defined (e.g. planned and potential cold/hot water mixing/stratification points), these shall be considered when determining inspection scope and frequency.

The following items shall be included in the summary programme:

a) Those principles based on which programme updating and development are administered and according to which components and their inspection areas are chosen, among others
   - preparation and acceptance of programmes
   - general principles for selecting the areas, methods, extent and frequency of inspection
   - general principles for a risk-informed in-service inspection programme
   - procedures for reporting inspection results and evaluating flaw indications.

b) List of components and structures subject to in-service inspection for which the following information shall be given:
   - system
   - safety class
   - pressure vessels, pipelines, pumps and

valves to be inspected with their component identifications
- grouping into inspection areas for qualification
- material
- inspection method.

c) Description of equipment for inspection of the reactor pressure vessel and other main components.

d) Qualification principles for inspection procedures, equipment and personnel.

e) The necessary drawings
- structural drawings of components and structures with a significant impact on risk
- flow charts specified by safety class.

f) Potential deviations from the ASME Code, Section XI [2], requirement level and justification for their acceptability.

4.3 Pre-service inspections

The purpose of pre-service inspections is to obtain data about the original condition of the areas of inspection within the in-service inspection scope before the nuclear power plant is started up to complement quality control of manufacture and installation, and to offer basic data against which to compare the results of individual in-service inspections. As far as possible, the inspections shall be conducted by the same methods, techniques and types of inspection equipment as are intended to be used in individual in-service inspections.

Pre-service inspections shall be repeated when a component or structure within the inspection scope is repaired, modified or replaced. These pre-service inspections shall be entered in the list of components subject to inspection.

The inspection procedures and equipment plus personnel shall be qualified as per Chapter 5 of this guide. The basic qualification of personnel and the approval of testing bodies are described in more detail in Guide YVL 1.3.

The following items shall be included in the pre-service inspection plan:

a) Description of testing bodies
- on-site organisation of inspections
- applicable working procedures
- qualification of personnel (Chapter 5).

b) List of inspection areas
- component/structure identification
- safety class
- unambiguous specification of welded joints and other areas of inspection (with the necessary reference to drawings)
- nominal dimensions of the inspection area
- structural material
- inspection category in accordance with ASME Code, Section XI [2]
- points of fatigue, etc
- inspection method
- inspection procedure
- limitations on inspection.

c) Detailed justification of choice of inspection areas in risk-informed in-service inspection.

d) Drawings of inspection areas
- flow charts indicating inspection areas by safety class
- drawings of components and structures with inspection areas marked on them
- detailed drawings of welded joints and other inspection areas, indicating the geometry and dimensions of each area.

e) Inspection procedures
- essential parameters
- qualification of procedures as per Chapter 5
- drawings of reference blocks with data on structural materials and applicable standards
- scan path sketches, if such are required to establish the scope of inspection.

f) Inspection equipment
- essential parameters
- testing procedures for inspection equipment
- qualification of equipment as per Chapter 5.

g) Potential deviations from ASME Code, Section XI [2], requirement level and justification for their acceptability.

The above information shall be given on inspections carried out during manufacture and installation if they replace some of the pre-service inspections. Pressure vessels shall be inspected after pressure testing, and supports welded to the pressure-retaining parts of the vessels shall be inspected after hot functional testing (operating pressure and temperature).

The completion of pre-service inspections is required before STUK can ascertain in accordance with section 20, paragraph 2, point one of the Nuclear Energy Act (990/1987) that the nuclear facility meets its safety requirements.

4.4 Individual in-service inspections

The requirements of the pre-service inspection plan in subsection 4.3 apply to an individual in-service inspection plan. In each inspection-specific plan, the inspections conducted and the inspection procedures and other documents revised since the previous inspection shall be given.

Individual in-service inspection plans shall be drawn up such that, during inspection intervals, the required number of inspections is completed in accordance with the summary programme. Fulfilment of the inspection requirements shall be demonstrated by cumulative summary lists of the inspection history which show i.a. each area's inspection date and indications recorded.

Those inspection areas having flaw indications that need to be followed by increased inspection frequencies shall be specified.

4.5 Exceeding of acceptance standards

If a flaw indication exceeds the threshold specified in the acceptance standard, the necessary measures shall be taken. These could be repairs, structure replacements, safety analyses including fracture mechanical analyses, complementary inspections, extended inspection scopes, increased inspection frequencies and special measures to prevent and monitor flaw growth, or combinations thereof. An assessment of mechanisms affecting flaw generation shall always be presented.

Besides the established inspection technique, it is often advisable to perform inspections using supplementary techniques to accurately characterise, locate, orientate and size flaws.

If flaw indications exceeding the threshold specified in the acceptance standard are detected in in-service inspections, the inspections shall be extended to cover equivalent areas of inspection, as required in ASME Code, Section XI [2].

Components and piping, or parts thereof, in which flaw indications exceeding acceptance standards are detected during in-service inspections must usually be repaired or replaced. Requirements for repairs and modifications are given in Guide YVL 1.8.

If the flaw indications are to be approved for operation on the basis of fracture mechanical analyses and without repairing or replacing the structure, the analyses can be made in accordance with the acceptance criteria of ASME Code, Section XI [2], Subarticle IWB-3600, or some other procedure separately approved by STUK. As further justification, calculations based on **L**eak **B**efore **B**reak (LBB) may be presented. The effect of ambient conditions on the flaw growth rate shall be considered and the values used shall be justified. In a cladded structure, also the effect of cladding shall be taken into account. Possible flaw growth shall be monitored by increasing the inspection frequency as per ASME Code, Section XI [2], until it can be demonstrated that no significant flaw growth occurs during the inspection interval.

Further measures shall be required in cases where, on the basis of fracture mechanical analyses, flaw indications exceeding acceptance standards are permitted in a structure. The measures aim to prevent and observe flaw growth during the subsequent inspection interval. The measures may be based on the origin of the flaw, the type of structure and material, the ambient and operating conditions and the estimated flaw growth rate.

An organisation conducting demanding strength analyses shall have a quality management system for strength analysis as required in subsection 4.1 of Guide YVL 3.5.

Recorded new flaw indications, or indications which have grown compared with previous inspections, shall be submitted to monitoring case by case by increasing the inspection frequency to detect any growth before the indications reach limits specified in acceptance standards.

An example of decision-making when a limit specified in an acceptance standard has been exceeded is given in Appendix 1.

4.6 Documentation and updating of in-service inspection

In-service inspection programmes and reports of inspection results shall be available for the entire operating life of the nuclear power plant. Special care shall thus be taken to ensure that documents are accurate, their wording unambiguous and the filing and updating system explicit.

The licensee shall have an explicit filing and updating system for the in-service inspection documents, which covers all documents relating to in-service inspection. The documents shall have unambiguous headings and terms in accordance with this guide.

Guide YVL 1.9 sets forth that in-service inspection programmes and procedures are to be regularly reviewed for possible need of revision, and for adequacy. The documents defined in subsection 4.1 shall be regularly reviewed and, if necessary, revised. The in-service inspection programmes with procedures may have to be revised due to the following reasons among others:

- changes in standards and requirements
- improved inspection techniques
- inspection experience
- feedback on the qualification system
- nuclear power plant operating experience in Finland and elsewhere.

If it has not been possible to perform an inspection required by STUK due to technical difficulties, the inspection shall be included in the programme again without a separate request when the facilities for performing the inspection have improved due to technical advances.

When risk-informed methods are used in choosing components for inspection, changes in the facility itself or in the probabilistic safety analysis may bring about a need to change the process of selecting inspection objects.

If STUK in its decisions requires that inspections similar in character to those presented in this Guide are to be carried out periodically, these are added to the in-service inspection programmes and are dealt with in accordance with this Guide.

The licensee shall see to it that all documents are amended accordingly without delay.

5 Qualification of an inspection system

5.1 General

An inspection system means all those elements of non-destructive testing that can influence the quality and outcome of an inspection, such as inspection equipment and their software, inspection procedures and inspection personnel who calibrate the inspection equipment, record inspection data, detect defects and characterise and size them.

Inspection qualification means the systematic assessment, by all those methods that are needed to provide reliable confirmation, of an inspection system to ensure it is capable of achieving the required performance under real inspection conditions. Each inspection system shall be qualified for in-service inspections such that it reliably detects, characterises and/or sizes defects endangering structural integrity and nuclear safety.

The report stating the common position of European regulators on the qualification of NDT systems [18] relates the qualification of inspection methods applied in the in-service inspection of nuclear power plant pressure equipment to nuclear safety.

As regards inspection qualification, this guide concerns ultrasonic and eddy current inspection systems for in-service inspection. Similar principles may also be applied in the qualification of other non-destructive inspection methods.

Qualification consists of practical trials to be conducted using test pieces representing the inspected components, and/or of technical justification providing evidence of inspection system performance based e.g. on physical reasoning, parametric studies, experimental data and assessment of inspection equipment and data processing systems or modelling [10].

The licensee is responsible for organising qualification and using in its implementation the services of a testing body and a qualification body. On the basis of sections 19 and 20 of the Nuclear Energy Act (990/1987), the licensee shall have available the necessary expertise and economic resources.

The licensee shall incorporate in the strategy plan for qualification (subsection 5.2) general guidelines on essential qualification requirements and procedures. The guidelines shall also accurately define the operation of the qualification body.

Inspection qualification is described in Appendix 2. The figure in the Appendix contains the tasks of all parties to the qualification process and also the qualification system's most important elements. It also shows how the inspection system can be developed by means of a feedback system and presents the interactions involved in technical justification within the framework of the entire qualification process.

5.2 Strategy plan for qualification

The licensee shall draw up a strategy plan for qualification, setting out the procedures and implementation of inspection qualification. The plan is to contain the below documents

- general guidelines setting out qualification requirements and methods, the qualification organisation and its quality management system and how the system relates to the entire quality management system of the licensee
- a nuclear power plant unit specific overall inspection qualification scheme containing, among other things, information on forthcoming objects of qualification, their preliminary qualification grouping and qualification levels as well as a preliminary schedule for the implementation of qualification
- guidelines on qualification, for example definition of qualification level, operation of qualification body, drawing up of technical justification, and practical trials
- procedures for management of essential parameters.

Components similar from the inspection point of view can be grouped into qualification groups such that qualification is conducted for all of them at the same time, thus reducing the number of individual qualifications. The grouping, as well as a group's practical trials, is to be justified by an analysis of any differences in essential input parameters. The essential input parameters of a qualification group are to be the same or equivalent.

5.3 Qualification body

The licensee shall have a qualification body for qualification management, implementation, control and assessment as well as the issuing of qualification certificates. The qualification body shall be competent and independent of the construction and operation of nuclear power plants as well as financial factors that could affect its work and decisions. The general requirements for a qualification body and its operation are set forth in [17].

The personnel of the qualification body shall have diverse expertise and experience in the technical fields required to assess the capability of inspection systems to reliably detect, characterise and size flaws. At least one member of the personnel monitoring and assessing qualifications from the inspection technical point of view shall have Level 3 basic qualification for the inspection method in question according to a qualification system that complies with Standard SFS-EN 473 [19], or a corresponding system; in addition, extensive practical experience is required on factors that could affect inspection reliability in the in-service inspection of nuclear power plant components and structures.

A qualification body may also be qualification-specific. The licensee is responsible for assuring the continuity of qualification by setting up a qualification steering committee and assigning to it members who have sufficient expertise in the field.

The tasks of the qualification body and the steering committee are described in Appendix 3.

5.4 Qualification dossier

The qualification body and the licensee shall gather inspection system specific documents into a systematic dossier covering the entire qualification. Detailed recommendations for a qualification dossier can be found in [14]. The essential parts of a qualification dossier include

- qualification input information

- the qualification procedure
- technical justification
- a description of test pieces and practical trials
- the inspection procedure
- assessment report and qualification certificates.

5.5 Qualification input information

The licensee shall define the input information required for an inspection qualification prior to the drawing up of the qualification procedure and the start of the process of qualification.

Various qualification levels are used to focus the qualification process to safety-significant components. The choice of qualification level is affected by the nuclear risk significance of a defective structure and the reduction in the probability of failure arising from inspection.

A high inspection system qualification level is required of components and structures whose failure leads to serious consequences.

Lower qualification levels shall be unambiguously defined and justified. Justification considers component design, such as strength calculations, materials and manufacturing, operating conditions, potential failure mechanisms, their probability and consequences. It is then required that organisational units responsible for plant safety and experts in these technical fields define the qualification level and provide justification for it.

Defects included in input information can be divided into three groups as follows, based on the predictability and probability of their nature:

- specific defect; specific defects have been found in structures
- postulated defect; the initiation of defects of particular types is postulated in a particular structure
- unspecified defect; no specific failure mechanisms exist for the structure and the nature of potential defects is thus unknown.

Qualification defect sizes shall be defined for all components subject to inspection. In the qualification groups defects are defined for the most stressed component according to wall thickness. Of these, the defects most difficult to detect because of their size are chosen as qualification defects. Qualification defect size is primarily based on defects allowed during nuclear power plant operation by the standard applied in the design of the component or structure in question. A calculation method that complies with ASME Code, Section XI [2], Subarticle IWB-3600 covers pressure equipment crack growth during pressure equipment inspection interval or during its remaining service life and safety factors that are in accordance with the service loadings in question.

Essential input information includes

1. Information on the component to be inspected
   - dimensioning and geometry
   - materials and manufacturing techniques
   - dimensioning and geometry of welded joints as well as welding processes
   - surface conditions and claddings
   - environmental conditions e.g. accessibility and radiation level
   - potential compression stresses in inspected area during inspection
   - previously detected defects.

2. Qualification level of inspection system to be qualified

3. Objectives of in-service inspections
   - detection capability
   - type, size, position and orientation of defects to be detected, characterised and sized
   - required accuracy of sizing and positioning.

4. Qualification objectives as well as acceptance and rejection criteria
   - detection capability
   - type, size, location and orientation of defects to be detected, characterised and sized
   - required accuracy of sizing and positioning .
   - allowable number of false calls.

5. Preliminary data on the inspection system to be qualified
   - equipment

- procedure
- personnel.

5.6 Qualification procedure

A qualification procedure is an inspection system specific document which systematically describes how a system is to be qualified. The qualification procedure shall be drawn up such that the results of qualification can be assessed against it. The procedure shall include at least the following facts: effect of quality level, balancing between technical justification and practical trials, information required of the testing body, the method of assessment of technical justification and inspection procedure and equipment, additional personnel qualification, guidelines for conducting practical trials, information on test pieces as well as assessment criteria for the entire inspection system.

It is recommendable to conduct qualification of equipment and procedure separately from qualification of personnel because otherwise it will be difficult to differentiate any weaknesses of the inspection system.

If the inspection system is qualified as an entity, all factors concerning the qualification of inspection equipment, procedures and personnel shall be considered.

The drawing up of a qualification procedure and its contents are dealt with in detail in [10, 14].

The qualification procedure is prepared on the basis of the input information presented by the licensee. It can be drawn up separately for the inspection procedure, equipment and personnel. The qualification procedure may be divided into two parts: qualification plan and so called qualification procedure document. The qualification body shall assess the qualification plan before control and implementation of the qualification process are started and it shall complement it by means of the qualification procedure document to meet the requirements of a qualification procedure.

The information to be contained in the qualification procedure is set forth in Appendix 4.

The figure in Appendix 2 presents the qualification procedure as part of the qualification process as regards time and performance.

5.7 Technical justification

5.7.1 General

A technical justification means information collected by the testing body, which provides evidence that the inspection system can meet its stated objectives. Technical justification is most generally used to justify test pieces and their defects as well as the inspection procedure, and to present the inspection equipment selection criteria.

A technical justification may, for applicable parts, contain physical reasoning, mathematical modelling and experimental evidence such as results of other qualifications and round robin trials or authenticated practical experiences. Physical reasoning is needed in the early phases of the qualification process already, when practical trials are planned.

The figures in Appendices 2 and 5 illustrate the structure of a technical justification, the mutual interactions of different parts, and the entire qualification process. Technical justification shall deal with the matters listed in Appendix 5 for applicable parts.

A technical justification is intended to

1. complement qualification conducted by practical trials, which is limited by the statistically limited number of test pieces, utilising all evidence supporting assessment of the inspection system's capability to operate on the set requirement level
2. complement and generalise the results of a practical trial by providing evidence that, if test results on the defects of individual test pieces meet the acceptance criteria, corresponding acceptable results could have been obtained even of such defects included in the input information as are not included in the test pieces
3. provide technical bases for the planning of sufficient practical trials
4. provide technical bases for the choice of an inspection system's essential parameters and their tolerance or range.

The meaning, contents and drawing up of a technical justification are discussed in detail in ENIQ Recommended Practices [11, 12, and 13].

The evidence for technical justification may often have a restricted scope of validity and this shall be borne in mind and brought up when drawing up and using technical justification.

5.7.2 Essential parameters

The definition of an inspection system's influential and essential parameters as well as the analysis of essential parameters is a vital part of technical justification. Parameters are discussed in detail in [11].

The factors which have an influence on the quality and outcome of a particular inspection are called influential parameters. The degree of their influence shall be assessed and, based on the assessment, some are to be classified as essential parameters. Parameters are either fixed parameters with a fixed value and tolerance or parameters within a range. Essential parameters shall be analysed in the early phases of technical justification. They are to be classified into three groups as follows:

- input parameters, which include e.g. component materials, dimensions and other characteristics; types, sizes, location and orientation of defects to be detected
- procedure parameters, which include e.g. beam angles and frequencies as well as recording levels
- equipment parameters, which include e.g. linearity of display as well as the positioning and repeatability accuracy of scanner.

The parameters of an inspection procedure shall be chosen based on input information parameters in a way ensuring accurate detection, characterisation and sizing of a component's defects. Technical justification shall demonstrate the applicability of the choices made and provide evidence of inspection system capability as obtained by means of the parameters chosen.

The parameters of inspection equipment are determined based on the inspection as a whole and their choice is influenced by both input and inspection procedure parameters.

An analysis of influential parameters and essential parameters includes the following phases:

- division of influential parameters into three groups: input information, inspection procedure and equipment parameters
- analysis of parameters into essential and non-essential
- division of essential parameters into parameters fixed within a tolerance and those within a range
- definition of the value and tolerance/range of essential parameters of the input group pertaining to the component and the defects to be detected
- definition of the acceptable tolerance and range of essential inspection procedure and equipment parameters, considering the inspection objectives and essential parameters of the input group.

The conclusions of technical justification shall contain a list of essential parameters within a range and essential parameters whose value has to be fixed within a tolerance together with their tolerances and ranges, the adherence to which is a condition of the validity of a qualification.

The essential parameters of an inspection procedure with their tolerances or ranges shall be contained in the procedure.

5.8 Practical trials

5.8.1 Test pieces

Test pieces and their defects shall be based on the essential input parameters and the requirements of the inspection technique chosen on the basis of physical reasoning. The test pieces and defects may have to be complemented on the basis of the qualification procedure and/or technical justification. Physical reasoning shall be included in technical justification (figures in Appendices 2 and 5).

Test pieces manufactured for other purposes can be utilised in qualification. In such a case, suitability for the qualification in question shall be evidenced by including an analysis of essential input parameters in technical justification. Any restrictions and the possible need for other complementary justifications, test pieces and tests shall be investigated.

In the design of test pieces, special attention shall be paid to such input information and inspection system essential parameters as cannot be sufficiently covered in technical justification due to insufficient evidence. These essential parameters as well as the inspection procedure and equipment parameters determine the requirements to be set for test pieces and practical trials.

Practical trials are discussed in [15].

The limited nature of practical trials is balanced by applying in design those cases worst from the inspection point of view. Worst case defects refer to such defects and component geometries, or other essential parameters, as are likely to represent the greatest challenges for detection and accurate sizing within a specific inspection qualification situation as defined in the input information and considering the specific inspection system used.

If the inspection objectives are achieved for worst case defects within the tolerance/range of essential parameters, even then other defects shall be manufactured in the test pieces, or it shall be proven by technical justification that the objectives are achieved within the tolerance/range of all essential parameters. The defects of test pieces shall simulate postulated or specific types of defects to an extent sufficient from the inspection technique point of view.

The tasks of a qualification body in the design and manufacturing of test pieces are set forth in Appendix 3.

The confidentiality of blind trial test pieces shall be maintained.

5.8.2 Implementation of practical trials

Prior to the start of the qualification process, and where necessary, the licensee shall acquaint the qualification body with the inspection system. The qualification body, for its part, shall guide the inspection personnel in the test arrangements of an open trial. The qualification body shall witness the trials and log all essential activities and events.

In qualification tests of inspection equipment, either mock-ups, or open or blind test pieces are used. During functional testing, the operator of the equipment is to closely follow the instructions for use of the equipment .Special care shall be taken to keep the accuracy of positioning and repeatability of the equipment within their tolerance range during assembly and disassembly. A list shall be made of those inspection equipment components subject to qualification.

The practical trial part of the qualification of inspection personnel shall be conducted by blind trials, separately of the qualification of inspection procedures and equipment, so that, in the case of a potential rejection, the unqualified part of an inspection system can be accurately defined for further development. Previously qualified inspection procedures and equipment are used in the trials. Whenever automated data acquisition and processing are used in mechanised inspections, even an analysis of previously recorded defect data can serve as a blind trial. Inspection personnel can be qualified for data recording, defect detection, characterisation and sizing all in one, or separately. Defect length and height can be separately sized as well.

5.8.3 Assessment of the results of practical trials

The qualification body shall assess the conducting and results of practical trials and justify its assessment in its report. A detailed description of practical trials and a report on their outcome plus the assessment criteria shall be included in the qualification dossier. Potential deviations from the inspection procedure and practical problems in trials shall be reported and their effect on the qualification outcome assessed.

The results shall meet the assessment criteria set forth in input information as per qualification procedure. The performance parameters defined in the input information, which are the objectives of qualification, pertain to the following factors: defect detection, false calls, accuracy of defect height and length sizing and accuracy of defect positioning . Each performance parameter is to be separately assessed.

The qualification of inspection procedures or equipment by practical trials is intended to demonstrate that the objectives of qualification are achieved by closely following the procedure. When the outcome of the trials is interpreted, the team of inspectors involved shall report their entire chain of argumentation in order to give evidence that the results were not obtained by justification external to the inspection procedure. The minimum amount of information that the qualification body needs to make its assessment includes all the necessary documentation on which indications are based and which explain and justify the interpretation of signals.

In the qualification of inspection personnel by practical trials an inspector shall demonstrate to the qualification body that he is capable of using qualified inspection procedures and equipment correctly and in a repeatable manner. The inspector must also be able to justify, if necessary, the various phases of the inspection process. By witnessing the inspection and reviewing the results, the qualification body shall gain adequate confidence that the inspection procedure is fully adhered to in personnel qualification.

The general principles of inspection personnel qualification are given in subsection 5.9.

The qualification of an inspection system is to be rejected in practical trials for example in the following cases:

- the stated objectives of qualification are not achieved
- the stated objectives of qualification are achieved but the chain of argumentation to interpret the results is inadequate
- the stated objectives of qualification are achieved but a written inspection procedure has been deviated from.

5.9 Qualification of inspection personnel

Inspectors shall have been qualified by a qualification system that complies with Level 2 of SFS-EN 473 [19], or they shall have an equivalent basic qualification for the inspection method in question. The basic qualifications dealt with in Guide YVL 1.3 shall be complemented by additional qualifications for the purpose of in-service inspection. Additional qualifications are inspection system specific and may require special training and experience, practical trials and a written examination. A general basic requirement is that inspection equipment and procedures have been qualified prior to personnel qualification.

Additional qualification with its assessment criteria depends on the inspection procedure and equipment as well as the details of an inspector's planned tasks. The requirements for additional inspector qualification shall be presented in the inspection procedure. They shall be individually assessed and justified on the basis of the inspection criteria in every inspection procedure's technical justification in conjunction with an analysis of essential parameters (figure in Appendix 5).

The qualification body shall assess the adequacy of the requirements of additional qualification and whether the qualification personnel meet the requirements.

Practical trials are discussed in subsection 5.8.

An inspector's qualification may be extended by technical justification, without a new practical trial, to qualify him to conduct inspections in accordance with other equivalent inspection procedures.

5.10 Qualification assessment report

The qualification body shall draw up a qualification assessment report. It shall be based on input information, the qualification procedure, technical justification and the results of practical trials as well as witnessing of qualification. The report is intended to describe how, in accordance with the assessment criteria presented in the qualification procedure, the inspection system meets its stated objectives of defect detection as well as characterisation of defect type, size, location and orientation.

A qualification assessment report shall contain

1. An assessment of the adequacy and restrictions of a technical justification in providing evidence of the meeting of an inspection system's stated objectives.

2. An assessment of the adequacy and restrictions of practical trials in demonstrating the meeting of an inspection system's stated objectives.
    - data on practical trials
    - an assessment of how the objectives of the in-service inspection system have been achieved

3. An assessment of the mutual complementarity of technical justification and practical trials
    - applicability of an inspection system's scope within the range of its essential parameters
    - scope of the range of essential parameters

in both technical justification and practical trials.

4. A summary of the outcome of practical trials.

5. Deviations from the qualification procedure and recommended future qualifications.

6. Factors potentially restricting the scope of qualification plus their causes.

7. Conclusions concerning the achievement of stated objectives and grounds for the issuance of qualification certificates as well as recommended actions to develop an inspection system.

Reporting on qualification is dealt with in [10, 14].

5.11 Qualification certificates

5.11.1 Issuing of qualification certificates

A qualification body shall draw up qualification certificates of all approved qualifications such that qualified inspectors, inspection procedures and equipment as well as their scopes and restrictions are specified. The certificate shall bear the qualification body's signature.

Qualification certificates for inspection equipment and procedures shall present the below information:

- identification of equipment and software
- identification of inspection procedure, its revision identification, name and date
- scopes with their restrictions
- references to input information documents
- references to the qualification assessment report
- date
- signatures.

After the conducting of a qualification, the qualification body shall draw up personal qualification certificates for the inspection personnel, which state qualifications and give scopes of competence with their restrictions and inspection procedure references in detail. The qualification certificates state the components subject to inspection and the inspection tasks qualified for them as well as essential information on the inspection equipment used for the qualification.

The qualification certificates issued for inspection procedures and equipment are valid until further notice, taking into account the restrictions mentioned in subsection 5.11.2.

Qualification certificates of inspection personnel shall present the below information:

- name of person
- identification of inspection procedure, its revision identification, name and date
- identification of inspection equipment and software
- scopes of competence with their restrictions
- references to an assessment report
- an inspector's basic qualification
- validity of certificate
- date
- signatures.

The qualification certificates of inspection personnel are valid for five years on the following conditions:

- The qualification of the testing body, i.e. the employer, is valid.
- The inspector shall have a valid level 2 basic authorisation for the inspection method in question according to a qualification system that complies with Standard SFS-EN 473 [19], or a corresponding qualification.
- The inspector verifiably works regularly such that he uses in-service inspection procedures and equipment.
- The inspector annually receives training relevant for his task and is given training in his specific field of competence prior to the start of inspections.

5.11.2 Withdrawal or review of qualification certificates

The qualification body (or the steering committee referred to in Appendix 3) shall withdraw the qualification certificates of an inspection procedure, or inspection equipment, if the qualified procedure, or equipment is found unreliable, or other serious shortcomings are detected in practice.

Withdrawal may be due to e.g. the below

reasons:
- Inspection conditions are not equivalent to qualification conditions.
- Inspection results are found out to be unreliable (the inspection system is incapable of detecting, characterising and sizing in practice the defect types for which it has been qualified).

If a qualified inspection system is modified such that the tolerances/ranges of essential qualification parameters are exceeded, the qualification body shall assess the pre-requisites for modification of the qualification scope and for review of the qualification certificates. Technical justification or additional practical trials may then be required.

The qualification body (or the qualification steering committee referred to in Appendix 3) shall report in writing to the licensee and the testing body any changes made to a certificate plus their causes.

5.11.3 Licensee obligations

The licensee shall update the lists of inspectors. The lists shall make reference, inspector by inspector, to the qualification certificates of inspection systems and STUK's decisions on them.

The licensee shall report in writing to the qualification body (or to the qualification steering committee referred to in Appendix 3) if the scope of qualification referred to in subsection 5.11.2 is exceeded, or if unreliabilities or other such shortcomings are detected as could lead to the withdrawal or revision of qualification certificates.

5.12 Storage of qualification documentation and test pieces

The licensee is responsible for archiving qualification documents and storing test pieces. The qualification body shall define the confidentiality of the storage of qualification documents and test pieces. The qualification documents shall be stored for the entire service life of the nuclear power plant. The documents shall be updated to comply with feedback on practical inspections or additional qualification. In accordance with section 63 of the Nuclear Energy Act (990/1987), the licensee shall arrange for STUK's regulatory access to the archived copies of qualification documents and test pieces. In addition, corresponding rights shall be given to the qualification body separately for each qualification .

6 Control by the Radiation and Nuclear Safety Authority

6.1 Control of in-service inspections

6.1.1 Control in general

STUK oversees in-service inspections on site by reviewing documents and making follow-up inspections in an extent it considers necessary. Included are general arrangements for the inspections, reporting of results and flow of information between the various parties. The licensee shall deliver to STUK a preliminary inspection schedule for the main components, or for their parts, and assign a contact person. STUK designates those areas of inspection for which the exact time of starting must be given.

When programmes are revised the licensee shall mark all changes clearly, justify them where necessary and submit all amended program pages to STUK for approval. A covering letter shall advise how the amended parts are to be included in the entity of documents previously provided.

The documents shall make unambiguous reference to documents about the same matter that may have been submitted to STUK earlier.

When an operating plant's in-service inspection programme is replaced by a risk-informed in-service inspection programme the licensee shall submit to STUK for approval a document stating the approach and scope chosen.

6.1.2 In-service inspection principles and the summary programme

The licensee shall submit to STUK
- when applying for a construction licence in accordance with section 35 of the Nuclear Energy Decree (161/1988), a description of the in-service inspection principles as part of the Preliminary Safety Analysis Report
- when applying for an operating licence, an in-service inspection summary programme in

accordance with subsection 4.2 of this guide for approval in accordance with section 36 of the Nuclear Energy Decree (161/1988).

6.1.3 Control of pre-service inspections

The licensee shall submit to STUK for approval the pre-service inspection programme of a new nuclear power plant unit, which complies with subsection 4.3 of this guide, not later than six months prior to planned inspection date.

The completion of pre-service inspections is required before STUK can ascertain in accordance with section 20, paragraph 2, point one of the Nuclear Energy Act (990/1987) that the nuclear facility meets its safety requirements. For this purpose, the licensee shall give STUK a written notification of the completion of the inspections, specifying

- inspections performed (reference is made to plans)
- inspection procedures used
- deviations from approved inspection plan and their causes
- flaw indications exceeding the acceptance standard and further action thereupon.

The licensee shall submit reports summarising pre-service inspection results to STUK for approval within four months from the accomplishment of inspections.

A summary report shall include:

a) Summary of inspections performed
   - a description of the organisations participating in the inspection and their inspection personnel
   - inspections performed (reference is made to the plan)
   - a statement on the acceptability of inspection results
   - deviations from approved inspection plan and procedures, with justifications
   - flaw indications detected and further action taken or planned thereupon
   - development needs as regards in-service inspections.

b) Detailed list of inspections performed
   - welded joints and other areas of inspection, inspection category in accordance with ASME Code, Section XI [2]
   - components subject to inspections not based on ASME XI (mixing, stratification and fatigue points, etc)
   - methods of inspection
   - reference to inspection procedures (revision identification) in each inspection area
   - indications detected and their characterisation
   - reference to inspection records
   - reference to characterisation records and other supplementary analyses
   - reference to deviation reports, if any.

c) Description of flaw indications exceeding recording level
   - inspection area
   - characterisation records for flaw indications
   - definition of size, character, location and orientation of flaw indications according to ASME Code, Section XI [2] and their comparison with acceptance standards, or a case-specific safety analysis containing fracture-mechanical calculations
   - an assessment of the causes of a flaw
   - a statement signed by experts on the acceptability of flaw indications
   - further actions.

d) Inspection equipment and devices used.

6.1.4 Control of individual in-service inspections

The licensee shall send to STUK the individual in-service inspection documents identified below that comply with subsection 4.4.

Individual in-service inspection plans shall be sent to STUK for approval not later than one month prior to planned inspection date. The planned inspection date is generally the date when the outage of the plant unit in question starts.

Short descriptions (length, height and position) of flaw indications to whose monitoring shorter inspection intervals are applied shall be given in the inspection plan and reference shall be made to documents submitted to STUK previously.

If flaw indications exceeding the acceptance standard are left in the structure on the basis of fracture mechanical analyses, STUK's approval shall be sought for the analyses and other actions prior to reactor start-up from shutdown.

STUK shall be sent a written notification of the completion of individual in-service inspections that is equivalent to a notification of the completion of pre-service inspections. This is a prerequisite of STUK's approval of post-shutdown reactor start-up.

Reports summarising individual in-service inspection results shall be sent to STUK for approval within four months from accomplishment of the inspections or ending of maintenance outages. The reports shall include matters equivalent to those included in reports summarising the results of pre-service inspections; including a comparison to the results of earlier inspections, and a comparison of flaw indication sizes during different inspections.

A nuclear power plant unit specific summary of in-service inspections and a progress report for ongoing inspection interval shall be submitted to STUK for information every year. The below information shall be included:

- follow-up of inspections and conducted inspections
- follow-up of results and reported indications
- status of inspections and fulfilment of inspection scope.

6.2 Control of qualification

For the purpose of overall control of qualification, the licensee shall submit to STUK

- for approval, general guidelines contained in the qualification strategy plan (subsection 5.2)
- for information, other documents belonging to the strategy plan.

The licensee shall submit to STUK the following information concerning individual qualifications

- composition of qualification body and any deviations from the qualification organisation presented in the qualification strategy plan (for information)
- input information with justification in good time prior to the drawing up of the qualification procedure and the start of qualification (for approval)
- qualification procedure compiled by the qualification body (for information).

For assessment of the outcome of qualification, the licensee shall submit to STUK documentation on the results of qualification not later than three months prior to the date of commissioning of the inspection system.

The results documentation shall include the below information:

- qualification assessment report
- qualification certificates
- other final documents of the qualification dossier listed in subsection 5.4.

An assessment report drawn up by the qualification body shall be submitted to STUK for approval. Other results documentation shall be sent to STUK for information together with the assessment report.

It is the responsibility of the qualification body to directly report any faults to STUK.

The licensee shall report the review of qualification certificates with justifications to STUK in writing.

Pursuant to section 63 of the Nuclear Energy Act (990/1987), and for regulatory purposes, the licensee shall arrange for STUK access to the filing copies of qualification documents and test pieces.

When applying for approval for inspectors as per Guide YVL 1.3, the licensee shall send to STUK updated lists of inspectors and copies of the qualification certificates granted to them by a qualification body.

7 References

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2. ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, Division 1, Rules for Inspection and Testing of Components of Lightwater Cooled Plants, American Society of Mechanical Engineers, New York, 2001.
3. IAEA Safety Standards Series No. NS-G-2.6, Safety Guide, Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants, Vienna, 2002.
4. IAEA Safety Series No. 50-P-2, Safety Practices, In-Service Inspection of Nuclear Power Plants, Vienna, 1991.
5. Discussion Document on Risk Informed Inservice Inspection of Nuclear Power Plants in Europe, EUR 19742, ENIQ Report nr. 21.
6. USNRC Regulatory Guide 1.178, An Approach For Plant-Specific Risk-informed Decisionmaking Inservice Inspection of Piping.
7. ASME Code, Case N-577 “Risk-Informed Requirements for Class 1,2 and 3 Piping, Method B, Section XI, Division 1”, March 2000.
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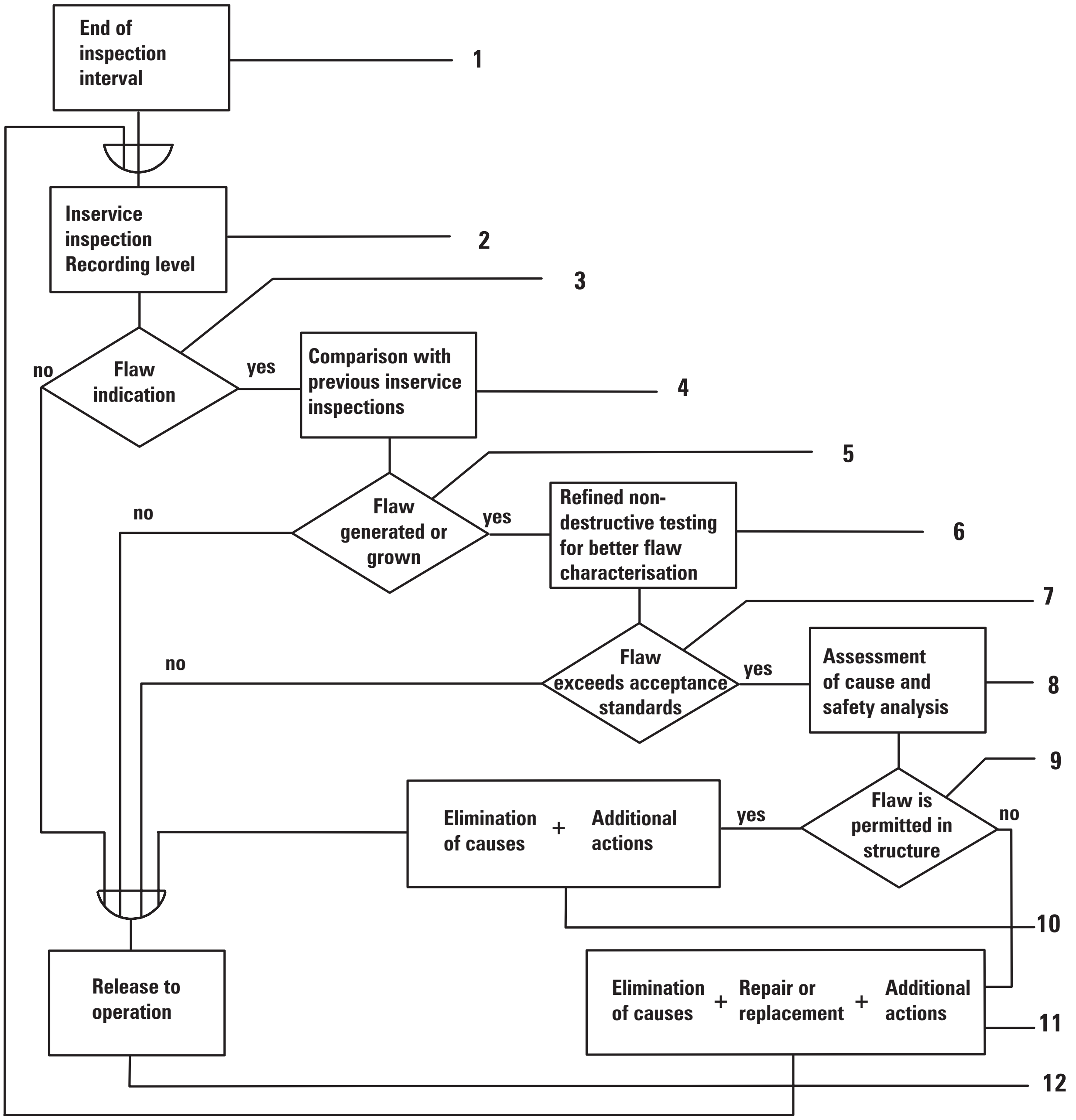
10. The European methodology for qualification, EUR 17299 EN, Brussels-Luxembourg.
11. ENIQ Recommended Practice 1: Influential/essential parameters, ENIQ Report 6, EUR 18101 EN, Brussels-Luxembourg.
12. ENIQ Recommended Practice 2: Recommended contents for a technical justification, ENIQ report 4, EUR 18099 EN, Brussels-Luxembourg.
13. ENIQ Recommended Practice 3: Strategy document for technical justification, ENIQ Report 5, EUR 18100 EN, Brussels-Luxembourg.
14. ENIQ Recommended Practice 4: Recommended contents for the qualification dossier, ENIQ Report 13, EUR 18685 EN, Brussels-Luxembourg.
15. ENIQ Recommended Practice 5: Guidelines for the design of test pieces and conduct of test piece trials, ENIQ Report 14, EUR 18686 EN, Brussels-Luxembourg.
16. ENIQ Recommended Practice 6: The use of modelling in inspection qualification, ENIQ Report 15, EUR 19017 EN, Brussels-Luxembourg.
17. ENIQ Recommended Practice 7: Recommended general requirements for a body operating qualification of non-destructive tests, ENIQ Report 22, EUR 20935 EN, The Netherlands.
18. Common position of European regulators on qualification of NDT systems for pre- and in-service inspection of light water reactor components, EUR 16802 EN.
19. SFS-EN 473 Non-destructive testing. Qualification and certification of NDT personnel. General principles.

Appendix 1 Evaluation of the inspection results



Flow chart for evaluation of the inspection results [4]

Appendix 1

In the flow chart for evaluating the inspection results, the evaluation process may proceed as follows:

1. In-service inspections are conducted before the inspection interval ends.

2. In-service inspections are performed and indications exceeding the recording level are recorded.

3. Indications exceeding the recording level are characterised and it is investigated whether they are geometrical or flaw indications.

4. The flaw indication is compared against the results of previous in-service inspections.

5. It is investigated whether the flaw is new or has grown.

6. The type, location and size of a new or grown flaw is characterised by refined NDT, if necessary.

7. It is investigated whether the flaw indication exceeds the limits specified in acceptance standards.

8. A safety assessment is performed for any flaw indication larger than the limits specified in the acceptance standard and the cause of the flaw is assessed.

9. After the cause of the flaw is assessed and a safety assessment performed it is decided whether the flaw is allowed in the structure.

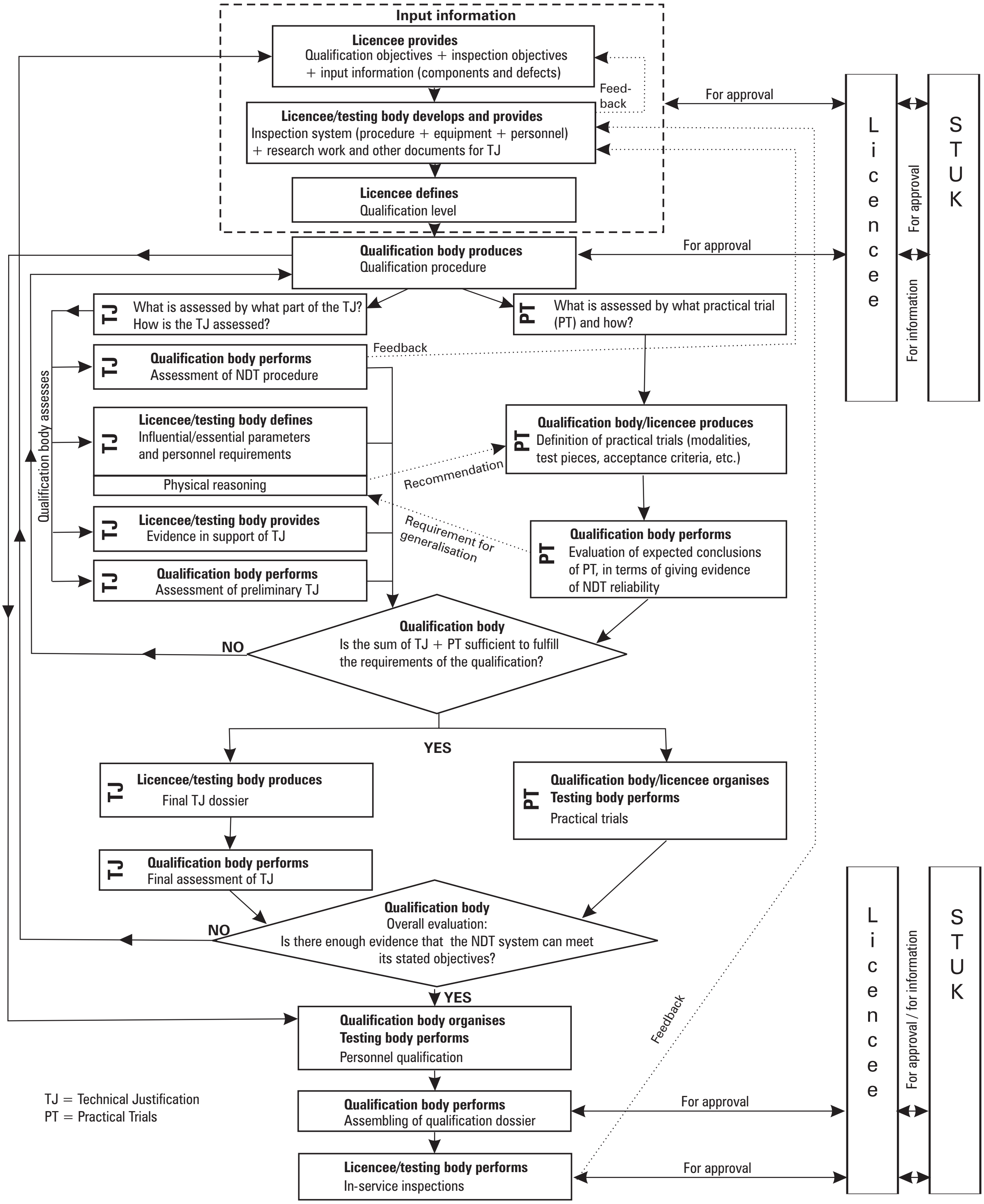
10. If the flaw is allowed in the structure, it is assessed what further measures are required to eliminate its causes and to prevent its growth.

11. A defective structure is repaired or replaced and new pre-service inspections are conducted. The flaw's causes are eliminated and the need for further measures is assessed.

12. A decision is made about the structure's fitness for its purpose.

Further measures may be e.g.:
- restrictions or alterations to operating conditions
- continuous flaw monitoring
- structural modifications such as weld overlays or modifications of supports
- additional inspections and reduction of inspection interval.

Appendix 2 Qualification process of inspection system



The figure illustrates the qualification process of the inspection system and presents interactions in technical justification within the entire qualification. It includes the tasks of the various parties to qualification and the most important elements of the qualification system. It also illustrates how the inspection system can be improved through a feedback system.

Appendix 3 Qualification body and steering committee

The reliability of qualification is vitally dependent on the competence and independence of the qualification body.

The tasks of the qualification body are as follows:
- directly report any faults to STUK
- produce check lists for control and inspection of e.g. input information, inspection procedure, technical justification and practical trials
- draw up the qualification procedure
- assess inspection procedures and technical justification
- assess what requirements have been set for the competence of inspection personnel
- determine the balancing between technical justification and practical trials
- assess detailed plans for each test piece and decide about their approval
- assess manufacturing of test pieces and prepare a report for inclusion in the qualification dossier
- prior to the start of qualification, visually inspect test pieces and review documentation pertaining to quality control as well as draw up information for inclusion in the qualification dossier and a statement on approval
- prepare a procedure for the assessment of qualification results
- monitor practical trials and assess their outcome
- evaluate how requirements pertaining to additional qualification of inspection personnel have been met
- update qualification documents with observed needs for modification
- assess qualification documents, draw up a qualification assessment report, and issue qualification certificates for inspection equipment, procedures and personnel.

The steering committee's work shall be part of the licensee's quality management system. Development and co-ordination of qualification activities is the task of the steering committee. The tasks are i.a. as follows
- to see to the continuity of qualification activities
- to arrange for the drawing up of a national qualification methodology
- follow international qualification activities and apply procedures in the development of national qualification
- assign a qualification body for each qualification and assure its independence and competence
- determine the focus of annual special training pertaining to additional qualification of inspection personnel and approve training plans
- withdraw qualification certificates, where necessary.

Appendix 4 The qualification procedure

The qualification procedure contains i.a. the below information:

1. A summary of input information on which the qualification procedure is based in accordance with subsection 5.5.

2. Preliminary assessment of the inspection procedure performed by the qualification body
   - preliminary assessment of the inspection procedure: is it unambiguous, systematic and detailed enough and also, does it identify all essential inspection procedure parameters.

3. Requirements for the elements of qualification as per each qualification level
   - procedures
   - equipment
   - personnel
   - technical justification
   - test pieces.

4. Balancing between technical justification and practical trials in qualification [13].

5. Assessment procedures [14] for
   - technical justification
   - inspection procedure
   - equipment
   - personnel.

6. Plan for implementation of practical trials [10, 15]
   - determination of the need for open and blind trials
   - management of blind trials
   - a description of the test conditions with time limitations
   - plan for trials
   - qualification schedule and place of practical trials.

7. Detailed information on test pieces used in practical trials [15]
   - number, types, dimensions, materials
   - equivalence of test piece and actual component to be inspected
   - identification of defects in open test pieces.

8. Recording of qualification results [3, 10, 15]
   - assessment report
   - qualification certificates.

9. Feedback system to develop inspection system by qualification and to obtain feedback on inspections for qualification.

10. Filing of qualification documents.

11. Management and storage of test pieces.

Appendix 5 Technical justification

The detailed contents of each technical justification depend on the object of qualification. Some of the below details of technical justification may be omitted or truncated [12]:

Summary
- a description of the layout of technical justification
- components covered by technical justification
- inspection objectives and how technical justification provides evidence of their fulfillment
- test pieces
- weight of technical justification against practical trials
- limitations of technical justification.

1. Introduction
   - components covered by technical justification
   - purpose of technical justification
   - description of the layout of technical justification.

2. Summary of relevant input information

3. Overview of inspection system
   - outline description of inspection procedure, equipment and personnel to be qualified.

4. Analysis of influential parameters
   - basis of technical justification (subsection 5.7.2)
   - identification of essential input, inspection procedure and equipment parameters [11].

5. Physical reasoning
   - qualitative reasoning for choice of procedure/equipment parameters considering component defects that are to be detected, and correctly characterised and sized
   - justification for test piece design.

6. Theoretical evidence
   - mathematical modelling [16].

7. Justification for qualification grouping
   - analysis of the different components in the proposed group to substantiate their similarity for the inspection system to be used.

8. Experimental evidence
   - relevant results from previous qualifications, results from reference tests, round robin trials, experimental studies and well documented and validated field experiences.

9. Parametric studies
   - studies on the influence of parameters listed in point 4, which have not been discussed above in points 6 and 8.

10. Equipment and data analysis considerations
    - evidence in support of the qualification of inspection equipment pertaining to an analysis of essential parameters as per point 4.

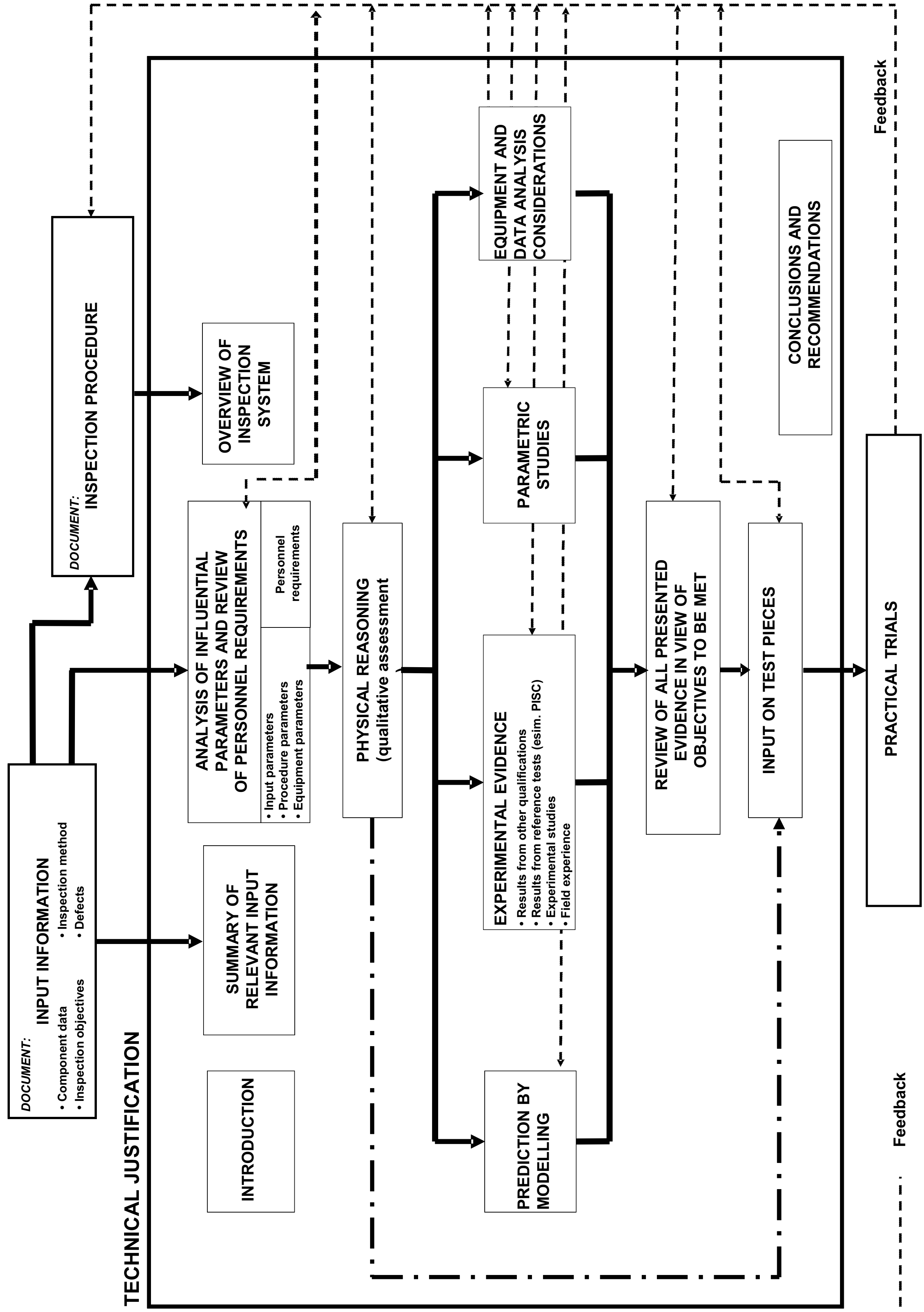
11. Statement of the adequacy of the inspection procedure
    - the inspection system's capability in defect detection and sizing, based on available evidence.

12. Review of qualification requirements for inspection personnel
    - justification and review of the sufficiency of qualification requirements presented in the inspection procedure by comparison with inspection requirements
    - identification of the need for additional written examinations and blind trials.

13. Recommended open and blind trial test pieces
    - geometry, dimensions, materials, defects and accessibility of test pieces.

14. Conclusions and recommendations
    - all the important conclusions contained in technical justification
    - recommendations for i.a. test piece design, inspection personnel qualification requirements or inspection equipment design
    - list of essential parameters to be fixed within a tolerance and essential parameters covering a range with their tolerance/range; adherence to these parameters is a precondition of qualification validity.

Appendix 5



The figure illustrates the contents of technical justification, the mutual interaction between its various parts, how technical justification connects with practical trials and with the entire qualification system, and the development of the inspection system through feedback.