Current status

Released

okg
- a company in the E.ON-group

Document name
G16 PBM Testing regulations for mechanical device

Registration No.	Edition	Page	Enclosures
ÖVS/G16/0002E	5	1 (22)	1

Issuing date	Valid from	Valid until
23 January, 2014		

Title
PBM2 - Qualification scheme for qualification of NDT systems in Sweden - English translation

Issued by

Linguistic check	Christel Nilsson/GAA
Factual review	Åke Jonsson/UMK
Quality review	No
Project approved	No
Line approved	Paula Svensson/TMB/2014-10-24
External review	No
Released	Jesper Enocksson, TMB, 2014-10-24

Subject No.

Distribution
APN, GEM, SYE, AAJ, ELN, LGY, OHR, RSS, DXL, Publiceras på Kärnan, Enigt särskild distributionslista hos GAI

Classification level
Public

PBM2

QUALIFICATION SCHEME

FOR

QUALIFICATION OF NDT SYSTEMS IN SWEDEN

Edition 5, 23.01.2014

This document is jointly produced by the Swedish nuclear power companies.
All revisions must be approved by joint consultation.

Approved:

Pär Blombergsson Forsmarks Kraftgrupp AB, Åke Jonsson OKG AB and Anders Richnau Ringhals AB
Plant administrators of PAKT documents

Revision list

Edition	Reason for revision/Sections concerned	Issuer (sign/dept)	Issued (dd.mm.yyyy)
2	Thorough revision due to the regulation SKIFS 1996:1 issued by the Swedish Nuclear Power Inspectorate regarding revision of "the regulation SKIFS 1994:1 Mechanical Equipment in Nuclear Plants". Revisions due to aspects from review of issue 1 performed by licensees and SAQ Kontroll AB Kärnteknik		01-05-1997
3	Revised due to experience and comments from nuclear plant owners and SQC, as well as new data from ENIQ.		01-11-1999
4	Revision due to new regulations issued by the Swedish Nuclear Power Inspectorate for mechanical components in nuclear power plants, SKIFS 2000:2, that replaces SKIFS 1994:1		01-04-2001
5	Total review		23-01-2014

Table of Contents **Page**

List of Appendix

1 Introduction

1.1 Scope

The qualification scheme (PBM 2) represents the licensees' overall requirement specification for performing qualification of inspection systems in accordance with the requirements of SSMFS 2008:13 [1], hereinafter called the **regulations**. In addition to the regulations, PBM2 is based on ENIQ's European Methodology document [2].

PBM 2 contains definitions of key terminology, directions for the distribution of work and responsibilities between the parties involved, a description of the implementation of qualification and guidelines for the assessment of qualifications. It also includes quality assurance requirements for the qualification body and basic requirements for inspection personnel, procedures and equipment that are to be qualified.

To sum up, it is the licensees' intention that PBM 2 is to be the guideline interpretation of the regulations in questions of qualification.

In terms of requirement specifications, the content of PBM 2 concentrates on **what** is to be done. **How** qualification is to proceed so as to be effective while providing good technical results is covered by a *process description;* see Appendix 1.

1.2 The requirements

Chapter 3, section 11 of SSMFS 2008:13 [1] contains the following about qualification for in service inspection:

"Non-destructive testing (NDT) of reactor pressure-vessels and mechanical components in Inspection Groups A and B shall be performed with inspection systems which have been **qualified** to reliably detect, characterise and size those defects which can occur in the types of components in question.
Sizing need not however be included if repair or replacement work is performed due to signs of damage without prior analysis of safety margins according to chapter 2 section 6.

The licensee is responsible for ensuring that such **qualification** is monitored and assessed by a body that has an independent and impartial position, appropriate organisation with the technical competence necessary for the task in question and a quality system that is suitable for the purpose. This body must be approved by the Swedish Radiation Safety Authority."

Regarding inspection of repairs, manufacturing and installation, chapter 4, section 10 states:

""Non-destructive testing in connection with inspections under section 8 must be performed either with

– well-tried inspection systems that from experience have been shown to be able to reliably detect and characterise the faults and deviations that repair, manufacturing and installation processes can give rise to, or
– inspection systems that can be adequately assessed and qualified according to chapter 3 section 11."

2 Definitions

For a list of definitions used in PBM2, refer to PAKT Definitions [3].

2.1 Damage tolerance and defect sizes – definitions and effect on qualifications

Section 2.1 gives some clarifications regarding the definitions that are used in describing defect sizes in qualification.

For reporting of defects, refer to section 8.

2.1.1 Damage tolerance analysis

An analysis that takes into account the relevant KFM, load data and damage mechanism and which determines a component's damage tolerance, i.e. time until an actual or postulated defect reaches acceptable defect size.

The damage tolerance analysis is performed in order to determine the defect sizes that the qualified inspection system should be able to detect, characterise and size. The damage tolerance analysis is reviewed and approved by an accredited inspection body (AK).

2.1.2 Acceptable defect size

The largest defect geometry in which satisfactory safety margins for operation are deemed to exist according to applicable regulations and standards.

Acceptable defect size is determined by a damage tolerance analysis.

2.1.3 Qualification defect

A chosen defect size that is used as input data for a specific qualification, normally acceptable defect size less the growth that is calculated to occur under prevailing operating conditions between two consecutive inspections.

Qualification defects normally come from the damage tolerance analysis and may vary depending on inspection interval.

2.1.4 Detection target

The smallest defect (defined by the parameters depth, length, width, crack opening, depending on inspection method) that the chosen inspection system should safely be able to detect, characterise and, where appropriate, size.

The detection target is normally determined with the damage tolerance analysis as a basis and set so that it is equal to or less than the qualification defect. Often reduced by the tolerance for sizing in the case in question.

The value of this tolerance is of greatest significance when determining a new inspection interval after a defect has been detected. The tolerance should be kept low so as to increase the possibility of keeping to the planned interval even after inspection with a detected defect.

2.1.5 Example of determining inspection interval when a defect has been found

Figure 1 shows an example of a crack propagation diagram showing the connection between permitted defect growth and inspection interval with a detected defect detection target as a starting point. When performing an inspection in the plant and confirming that there are no defects, including measurement tolerance, greater than the **qualification defect,** the defect size can be used as a starting point for determining the new inspection interval.

If there at inspection in the plant is a reported defect that is greater than the detection target, the basis for determining the new inspection interval (max. 10 years) is the reported defect size plus measurement tolerance, or alternatively another action is taken (e.g. repair).

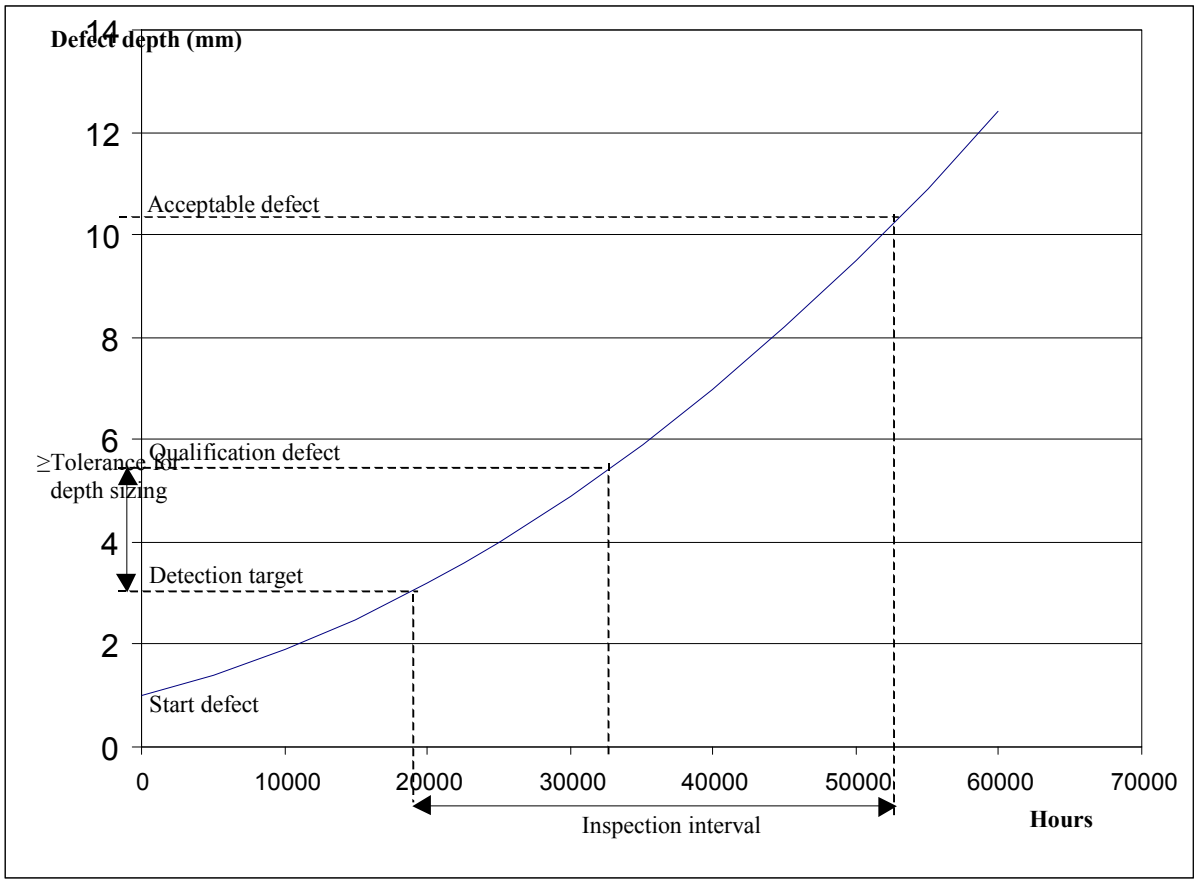

Figure 1 Example of a growth diagram, with associated definitions, for a component with detected defects ≤ detection targets. The permitted inspection interval is then calculated between the detection target and the acceptable defect size.

3 The parties' areas of responsibility and tasks

3.1 The Licensee (TH)

The licensee (TH) is responsible for ensuring that in-service inspection is performed according to the regulatory requirements, which includes ensuring that inspection of components in inspection groups A and B is carried out with inspection systems which are qualified. To fulfil these requirements, the licensee must:

- Contract inspection companies that are accredited for their task, so-called accredited laboratories (AL) in third-party positions.
- Have detailed knowledge of the inspection conditions for all relevant components and areas. This involves knowledge of materials, dimensions, manufacturing methods, accessibility for inspection and essential MTO (man, technique, organisation) factors. It also includes knowledge of repairs and other deviations from the intended design or manufacture.
- Produce a relevant defect and structural integrity analysis (DoS) for each component that is included in the qualification. The licensee may also choose not to use a DoS as a basis for the qualification. Instead the qualification can be designed as a performance test, where the qualification parameters (detection targets, tolerances etc.) are chosen to match the expected performance of the inspection system. In this case the corresponding DoS must be produced before inspection in the plant.
- Specify detection targets for each component that is included in the qualification.
- Carry out required investigations in connection with inspection for repairs, manufacturing or installation, to determine if the inspection systems in question can be regarded as well-proven. If this is not the case, also to determine the scope of qualification that is required.
- Order qualification by a qualification body (KO). Technical descriptions and purpose of the inspection, qualification documentation and schedules must be included with the order to the extent necessary.

- Support the accredited laboratory (AL) in its work of producing procedures, technical justifications (TM) and other data and otherwise in its preparations for qualification. TH must actively participate in all contact between AL and KO.

- When inspecting in the plant, ensure that AL reports any deviations compared to qualification documentation, i.e. if inspection is not in agreement with the qualified inspection procedure/technique. TH must report such deviations to KO for assessment.

- When inspecting in the plant, ensure that AL reports any deviations in scope of inspection, e.g. inspection limitations. TH must report such deviations to AK for assessment.

TH is responsible for ensuring that in-service inspection fulfils the requirements of the regulations. It is TH's responsibility to perform inspection group division, assign inspection objects inspection intervals and otherwise report damage tolerance for relevant components. These tasks are however not immediately linked to qualification activities and are governed in detail by PBM1. Investigation is performed by the relevant accredited inspection body (AK).

In connection with in-service inspection/qualification, TH must provide the following data to AK for investigation:

- Defect and structural integrity analyses (DoS) with associated damage tolerance analyses and defect descriptions for all inspection areas included.

- Certification of completed qualifications that are applied in implementing in-service inspection. Distribution: KO – TH – AL + relevant AK.

3.2 The qualification body (KO)

The qualification body (KO) supervises and assesses qualification of NDT systems in accordance with the requirements in SSMFS 2008:13.

Within the framework of the regulatory rules and the approval of the Swedish Radiation Safety Authority, KO must carry out its tasks in a way that promotes time and cost efficiency, without forgoing technical quality.

Technical instructions must be prepared for at least the following activities within KO:

- Preparation of qualification procedure and qualification dossier.
- Review of submitted qualification documents, including technical justifications.
- Test specimens: Specification of defects, requirements for procurement, handling, secrecy, fingerprint and test specimen data base.
- Carrying out qualification of procedures, equipment, personnel and complete systems.
- Issue, revision, withdrawal of qualification certificates. Including distribution to TH and AL.
- Storing qualification certificates in a certificate database.

If deviations arise during inspection in the plant that refers to inspection procedures/techniques, it is KO's responsibility to assess these at TH's request.

By agreement, KO then assists other parties with inspection competence, e.g. in the form of advice. This must naturally be done with consideration for the Swedish Radiation Safety Authority's requirement for impartiality and secrecy.

There must be instructions for confidentiality regarding customers' (AL, TH) commercial secrets, blind and open test specimens, qualification documentation and qualification results. At the qualification body, there must be non-disclosure agreements in place for all personnel, both permanent and temporary employees. The instructions must clarify what information is deemed to be confidential and who should have access to it, including what confidential information temporary staff may have access to.

There must be routines in place to ensure that unauthorised personnel and personnel taking part in the qualification cannot take information in any form away from the qualification body's premises. There must also be routines to ensure that information stored in computer media (hard disc or similar) is destroyed after qualification has been completed.

3.3 The accredited laboratory (AL)

The accredited laboratory (AL) carries out in-service inspection in the licensee's plant, with qualified inspection systems and must:

- Make the equipment, procedures and personnel available for qualification that is intended to be used for inspection in the licensee's plant.
- Produce technical justification (TM) and other necessary qualification data relating to the qualification to be performed. Technical justification normally follows the guidelines in ENIQ Recommended Practice 2 [4].
- Work according to a quality assurance system that fulfils the requirements of EN ISO 9001 or corresponding standard and thereby ensures that requirements for control, performance and documentation of all activities are fulfilled.
- Report the company's accreditation and certification for KO and AK.
- In qualification, follow the qualification body's procedures and other directions, including confidentiality requirements.
- Inform KO and TH of changes in equipment, inspection procedures or the tasks of personnel that might lead to a requirement for supplementary qualification.
- Before and during inspection in the plant, report any noted deviations of significance to completed qualification, for TH's assessment.

An AL is permitted to perform qualification without having a commission from a TH. In such a case, the accredited laboratory assumes appropriate parts of the licensee's tasks.

3.4 The accredited inspection body (AK)

The accredited inspection body (AK) has no active role in inspection qualification, but has tasks connected with in-service inspection carried out at the plant. The following tasks connected with qualification activities are performed by AK:

- Reviewing the damage tolerance analyses and associated defect and structural integrity analyses (DoS) produced by TH.
- Reviewing the inspection intervals determined by TH.
- Assessing completed inspections in the plant and certifying conformance with the requirements of the regulations. This means that AK must certify that inspections in the plant correspond to the qualification and are performed by an accredited laboratory.
- Reviewing and assessing reported inspection deviations with regard to scope of inspection, e.g. inspection limitations.

4 Qualification - in-service inspection

4.1 General

In the following, detailed instructions are given on carrying out inspection qualification for in-service inspection according to SSMFS 2008:13, chapter 3, section 11. Qualification that relates to procedures for inspection of repairs, manufacture or installation in accordance with SSMFS 2008:13, chapter 4, section 10 is performed to an appropriate extent according to these instructions; see section 5 of this document.

In terms of requirement specifications, the content of PBM 2 concentrates on **what** is to be done. **How** qualification is to proceed so as to be effective while providing good technical results is covered by a process description; see Appendix 1.

Detailed instructions for performing qualifications are produced by KO and reviewed and approved by the Swedish Radiation Safety Authority through its regulation of KO.

Unless there are specific reasons otherwise, the same edition of KO's technical instructions as applied at the time of procurement continue to apply throughout the qualification.

4.2 Qualification data

At the start of a qualification project, TH's project manager must ensure that quality-assured qualification data has been produced, including object-specific information. A project description must also be prepared.

The object-specific information should include, as a minimum:

– Damage tolerance analysis
– Defect and structural integrity analysis (DoS)
– Procurement data
– Qualification documentation

See more detailed directions in Appendix 1.

4.3 Defect specification

KO prepares defect specifications for the blind test specimens for the practical trials for personnel qualifications. These defect specifications are secret. The defect specifications for the open test specimens for procedure qualification are prepared by the licensee, but as they are an integral part of the qualification data they have to be reviewed by KO.

If TH so requests, KO must also be able to prepare the defect specifications and any necessary technical justification for the open test specimens.

It is important that the defects in the blind test specimens correspond closely to those specified for the open test specimens. KO must therefore design the blind test specimens to the same prerequisites as the open test specimens.

4.4 Inspection procedure

The inspection procedure, produced by AL, is the central input document for the qualification of an inspection system.

Before it is submitted to KO, it must first be reviewed by the TH to ensure that it is relevant to the inspection task to be carried out on site.

4.5 Technical justification

The technical justification (TM) is the key document in which all the theoretical evidence and reports of different trials, which provide evidence that the inspection system can meet its stated objectives, is compiled. The TM must include a measurement uncertainty analysis.

Technical justification normally follows the guidelines in ENIQ Recommended Practice 2 [4]. The inspection system's influential/essential variables should normally be given in the TM according to the guidelines in Recommended Practice 1 [5]. An example of a technical justification may be found in the report Enhagen 1 [6].

Before the technical justification is submitted to KO, it must first be reviewed by the TH to ensure that it is relevant to the inspection task to be carried out on site.

4.6 Qualification procedure

For each individual qualification KO draws up a qualification procedure. The purpose of the qualification procedure is to give detailed instructions for the specific qualification. TH and AL must be given the opportunity to comment on the qualification procedure before the actual qualification commences.

The qualification procedure must state how KO assesses the results of the practical demonstrations in the qualification.

4.7 Practical demonstrations for procedure and equipment qualification

If, after a review of TM has been performed, it is judged that practical demonstrations need to be performed, these must occur under KO's leadership according to predetermined instructions and an agreed qualifying procedure.

Inspection equipment must be prepared, checked and test-run before qualification begins. If assembly of the equipment on site is necessary, sufficient time must be allowed for checks and test runs.

Open test specimens are normally used for procedure and equipment qualification.

Qualification of equipment is normally performed together with a factory acceptance test (FAT).

A programme for equipment qualification/FATs is normally prepared by AL and reviewed and approved by TH and KO.

4.8 Personnel qualification

Qualification of personnel requires the existence of a qualified procedure and equipment. Practical trials for personnel qualification are normally carried out on blind test specimens. The qualification can apply separately to detection, characterisation, sizing, or all parts together. It can be divided into four elements:

– Data collection
– Detection
– Characterisation
– Sizing

The qualification may include individual elements or combinations.

Personnel who are to be qualified for data collection and assessment of inspection must be certified to at least level 2 according to ISO 9712 or another national standard with corresponding requirements. For other tasks with mechanised inspection, an assessment must be made regarding necessary basic personnel competence.

Qualification certificates for personnel are valid for 5 calendar years.

4.9 System qualification

Equipment, procedure and personnel qualifications for one and the same inspection system may be qualified together and then constitutes a system qualification. If any part of the system is changed a new assessment of the whole inspection system must be carried out.

4.10 Requalification

Requalification can become necessary for two reasons. Either personnel, procedures or equipment may have failed the qualification, or changes in the basis for qualification, equipment or procedures may call for an amendment of the qualification.

In the case of requalification because of a failure, the customer (TH and/or AL) must first show that appropriate measures have been taken to rectify the deficiencies that caused the failure.

Personnel who do not fulfil the stated requirements for one or more elements may only take a requalification during the course of one year.

In the case of requalification/amendment because of changes in the basis for qualification, equipment or procedures, the original qualification procedure is followed in relevant parts.

4.11 Reporting results

Results of qualification are reported by KO to the customer who has ordered the qualification, if not otherwise specifically stated in the order. Reports may also be provided to others by specific agreement.

Reporting to parties other than the orderer is an issue between the affected parties and not the responsibility of the qualification body.

The scope and validity of the qualification must be documented by KO.

Qualification of equipment and procedures has no time limit, provided there are no significant changes.

Personal qualifications have a time limit. The period of validity must appear in the documentation.

If reason arises to question an approved qualification, e.g. when the inspection purpose is not fulfilled when inspecting in the plant, KO must be notified with a written report and must then investigate the matter and propose whether the qualification certificate should be withdrawn. The affected AL and TH must be given the opportunity to comment before a decision is taken. The affected AL and TH must be notified in writing of a decision of certificate withdrawal. The decision must be properly justified.

4.12 Lessons learned

At the completion of each qualification project, a final meeting must be held, where all involved parties have an opportunity to exchange lessons learned.

In order to improve the process, lessons learned must be continuously documented and distributed to those affected by the qualification activities.

4.13 Appeals

Appeals to KO's decisions may be made to the Swedish Radiation Safety Authority.

5 Qualification - repair, manufacture and installation

5.1 General

SSMFS 2008:13, chapter 4, section 10 states: ""Non-destructive testing in connection with inspections under section 8 (of repairs, manufacture or installation) must be performed either with:

- well-proven inspection systems that from experience have been shown to be able to reliably detect and characterise the faults and deviations that repair, manufacturing and installation processes can give rise to, or
- inspection systems that can be adequately assessed and qualified according to chapter 3 section 11."

The general advice for the same section states: "In this case *well-proven non-destructive testing systems* mean those that

- are based on standardised methods, found in accepted product standards or similar rules for inspection of equivalent products with similar quality requirements, and
- have been used over a period of time, when experience of the ability to detect and discriminate has been documented for these methods, and
- whose practical application is controlled by instructions or procedures that include the necessary calibration- and handling instructions and also the appropriate technical and methodology acceptance standards.

In practice the above means:

1. TH must be in agreement with AK that the inspection systems used for inspection are in fact *well-proven*.
2. If this is not the case, the part of the inspection system that is judged not to be well-proven must undergo relevant qualification.
3. The qualification must be monitored and assessed by KO.

If defects are removed without subsequent repair (e.g. boat sample), the affected area must be inspected with a qualified inspection system according to chapter 3 section 11.

5.2 Assessment of "well-proven"

If there exist any doubt that an inspection system can be regarded as *well-proven*, TH must make an assessment according to the criteria in section 5.1 and present it to AK for compliance review, well in advance of the scheduled inspection.

5.3 Scope of qualification

TH (with the aid of AL) must analyse the needs and produce the necessary documentation for the qualification scope and documentation that is judged relevant for the specific case.

The qualification documents must be reviewed by KO. Investigation of compliance with the requirements of SSMFS 2008:13 is performed by AK.

6 Documentation

6.1 Qualification dossier

A document dossier must be created for every qualification. In this all the data, assessments, reviews and other information from the qualification in question are collected. When a qualification is completed the qualification dossier constitutes the complete documentation of the completed qualification. The dossier is kept on file by KO and is confidential. The quality assurance system of the qualification body must include rules to ensure that information from the qualification dossier is only made available to those parties who are authorised to see it.

6.2 Register of valid qualifications

KO must keep an up to date register of all completed qualifications. There must be links between personnel and procedural qualifications. Updating of the register must be continuous so that it is always correct.

6.3 Test specimen register

KO must keep an up to date register of all blind test specimens that KO has specified, as well as all open test specimens reported by TH or AL. The information to be found in the register, routines for updating and authority to use the register must be controlled by an appropriate instruction.

7 Test specimens

Test specimens are designed to simulate inspection situations for which a particular inspection system is to be qualified. The geometric shape can be identical with a particular component in a plant, but should normally be more general and represent several components. Defects to be implanted must be based on defect descriptions produced by TH and agreed by TH, AL and KO. There are two fundamentally different types of test specimen:

- Blind test specimens, for which information about the defects which have been implanted is kept strictly secret.
- Open test specimens, for which information about the defects implanted may be disclosed to persons undergoing qualification.

On account of the secrecy requirements regarding implanted defects in blind test specimens, the qualification body handles certain parts of the preparation process.

7.1 Quality assurance

Organisations that deal with test specimens (the manufacturer, TH, AL and KO) must have a quality-assurance system that ensures that classified information is handled correctly and that non-disclosure agreements required for staff in these organisations are adequate.

The test specimen manufacturer must work according to a quality assurance system that fulfils the requirements of EN ISO 9001 or equivalent. The test specimen manufacturer must also be approved by TH and KO for manufacture of the defect type in question.

Manufacture must follow a detailed manufacture and control plan. The manufacture and control plan must be reviewed and approved by TH and KO.

TH must audit manufacturers of test specimens to an appropriate extent, taking the scope of the order into account. KO must always be informed of such audits and invited to participate.

7.2 Fingerprinting and defect mapping

A fingerprint must normally be made for every test specimen made, to ensure the quality of the test specimen. The fingerprint is intended as an assessment of whether the test specimen's defect simulation fulfils the defect specification and represents an as-built map before procedure and personnel qualifications take place.

8 Reporting defects when inspecting with qualified procedures

Defects must be reported showing the greatest value for height and length. The defect can then be contained within a rectangle parallel with the object area.
The circumscribed rectangle represents the size of the defect; see figure 2.

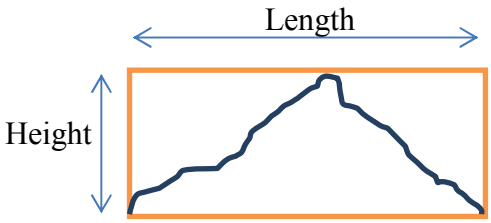

Figure 2 Size of defect

If one of the defect's measured dimensions (length or height) is less than the detection target, this measurement must be reported as "less than detection target".

If one of the defect's measured dimensions (length or height) is greater than the detection target, the actual measurement and the measurement tolerance must be reported.

9 References

[1] Strålsäkerhetsmyndighetens föreskrifter om mekaniska anordningar i vissa kärntekniska anläggningar (The Swedish Radiation Safety Authority's regulations on mechanical components in nuclear power plants), SSMFS 2008:13, ISSN: 2000-0987

[2] European Methodology for Qualification of Non-Destructive Testing, Third issue. 2007, ENIQ Report no. 31, EUR 22906EN.

[3] PAKT Definitions, issue 1.0, 01.09.2011.

[4] ENIQ Recommended Practice 2 – Strategy and Recommended Contents for Technical Justifications, Issue 2, 2010, ENIQ Report no. 39, EUR 24111 EN.

[5] ENIQ Recommended Practice 1 – Influential / Essential Parameters, Issue 2, 2005, ENIQ Report no. 24, EUR 21751 EN.

[6] An example of a technical justification - Enhagen 1, report 016/06, issue C.

PBM2 Appendix 1 Process Description

Contents **Page**

0 Introduction

PBM 2's main document describes ***What*** is to be done. The process description in this appendix describes ***How*** qualification activities are to be performed.

The process description has been divided into four parts, as found in sections 1-4 of this document. Also see the overview of the process in figure 1 and section 5.

Note that this is the normally preferred order of processes. Certain activities may however be performed in parallel or in a different order. This is, for example, decided by the scope and schedule of the qualification.

Deviations in the order of processes should, in advance, be agreed between the parties involved.

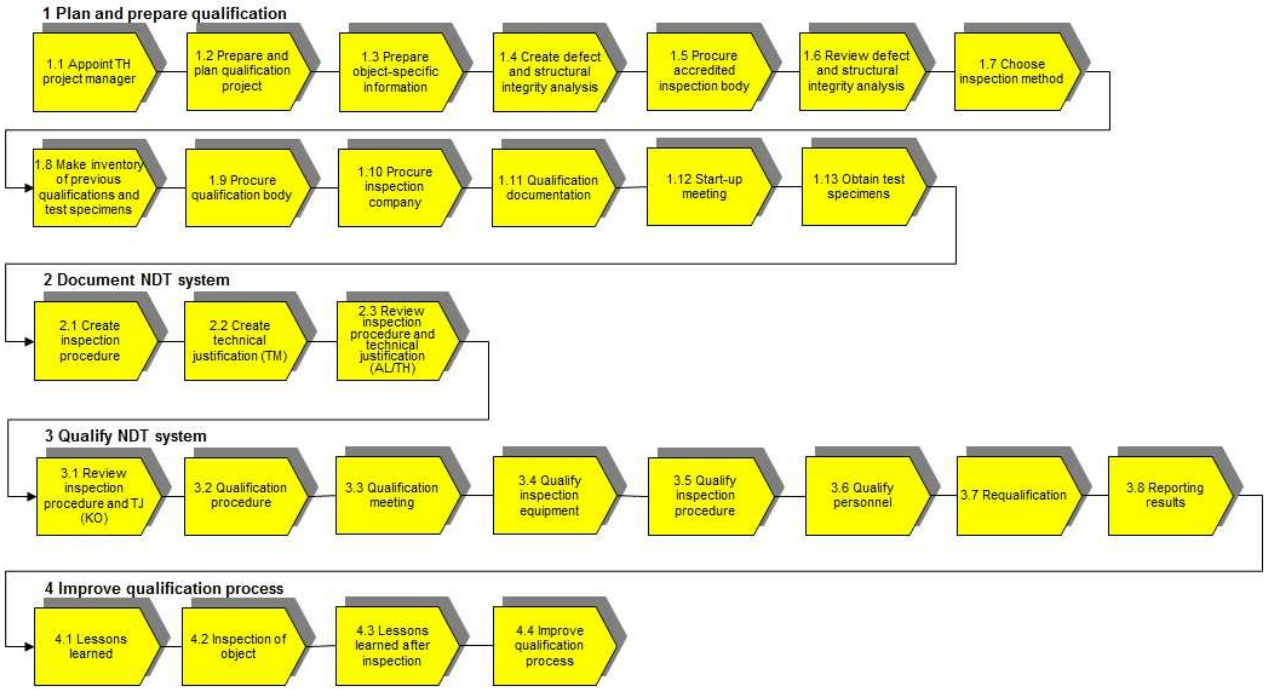

Figure 1 Overview, chart of the process

1 Plan and prepare qualification

The licensees (TH) are normally responsible for planning and preparing qualifications.

1.1 Appoint TH project manager

TH appoints a project manager, who must have the right education and training, experience and competence for this task. The project manager must also be assigned the required personnel resources and other aids, so as to be able to perform the qualification project successfully.

The project manager has complete technical and financial responsibility, and is also responsible for the qualification project's quality (safety, environment and finance).

The project manager should have fundamental knowledge of the inspection technique to be qualified. This includes responsibility for planning and controlling the qualification project's resources.

The project manager must continuously keep the parties involved informed of the progress of the work. The project manager must ensure that all decisions taken are documented. The project manager must also ensure that necessary decisions are taken. All changes in the qualification project and other significant events must be documented. The project manager must agree any changes in the project's scope with all affected parties in writing and must document them clearly.

1.2 Prepare and plan qualification project

1.2.1 Qualification data

Before a qualification project starts, the project manager must ensure that all data and information needed to start the project is available. The project manager must also ensure that the data is quality assured.

Preparing for a qualification project also involves producing object/plant specific qualification data and producing the necessary requirement specifications, schedules and tender documents for the qualification project. It is very important to have clear and well thought out requirement specifications, since these will be the basis from which further work is controlled.

1.2.2 Plan qualification

We know from experience that for major inspection projects there must be at least two years available from project start to implementation of inspection in order to complete qualification in an orderly fashion.

Usually realistic detail planning cannot be done until TH has ordered AL. It is important however that the power company gains an impression as quickly as possible of the probable time needed to complete a qualification project. Planning must be done before the qualification project begins and must be continuously reviewed thereafter.

While work is in progress, the project manager must stay informed about the progress of the work and any problems that arise that will require a special effort to find a solution.

With major qualification projects, it is often an advantage to divide them into sub-projects. It is important that sub-projects are well defined and demarcated and that interfaces with other sub-projects are clear.

1.2.3 Create a project description

Every qualification project must have a project description produced by the project manager. The description must include the information needed to be able to implement the qualification project. Material that has been produced during preparation becomes the basic data for the project. The project description must also include a resource plan, which forms the basis for allocating resources to the project.

The project description is created in order to clarify roles, safeguard requirements and clarify the need for resources.

1.2.4 Follow up

There must be routines for following up on finance, techniques, time and quality. There must be regular follow-up, which is reconciled against the plans for the project. All deviations from plans must be followed up and corrective measures taken. The project manager must document all important events in the project.

Financial deviations must be analysed and if possible rectified, as well as reported to those affected.

1.2.5 Meetings

Meetings have many purposes, which fall into three main groups: information, planning and decision making. The person who calls a meeting must clarify its purpose in advance. All meetings must have an agenda, even though this may be very simple in many cases.

Minutes must be kept of all meetings. In major projects, meetings must follow pre-set formalities for calling, presentation lists, minutes, adjustment of minutes etc. Minutes must be written and distributed quickly. For each item that is not settled, the minutes must state who is working on the question and when concrete results must be reported. The project manager calls and chairs meetings.

There must be a routine for how the specific qualification project is to be reported and with what frequency. It may be an advantage to specify in the routine which fixed meeting dates will apply during the course of the project. Reporting should include a list showing the status of all relevant documents.

1.3 Prepare object-specific information

Basic information from control documentation and a number of different items of object-specific information need to be identified for the production of different qualification documents, such as:

- Damage tolerance analysis
- Defect and structural integrity analysis
- Procurement data
- Qualification documentation
- Test specimen specifications.

Collecting object-specific information often requires access to areas that are only accessible during maintenance outages.

Appropriate parts of the following information from control documentation should be included:

- Identity number of the inspection object in question
- Drawings of the inspection object
- Welding instructions that state welding procedure, i.e. WPS
- Documents stating how heat treatment is performed
- Material certificate of materials included in the inspection object
- NDT records from prefabrication, assembly and in-service inspection
- Documented repairs and processing

- Documented deviations regarding dimensions, material thickness, internal and external geometrical variations, surface appearance
- Inspection limitations
- Ferrite content of austenitic castings.

Appropriate parts of the following MTO (man, technique, organisation) factors should be included:

- Ergonomic space for inspection personnel
- Working temperature
- Lighting conditions
- Noise level
- Need for scaffolding
- Surface and general dose rate at the inspection object
- Need for extra protective equipment.

1.4 Create defect and structural integrity analysis

The defect and structural integrity analysis (DoS) is defined in the PAKT definition list as follows:

"Defect and structural integrity analysis
A systematic analysis based on the component's constructive design, manufacture, installation, operating history and anticipated future operating conditions. The defect and structural integrity analysis (DoS) identifies probable damage mechanisms and describes anticipated defect types and appropriate inspection areas."

A defect and structural integrity analysis describes critical and acceptable defect sizes and the speed of growth of defects under current operating conditions in the environment in question, which gives the qualification defect size. Calculations are made for defect orientation according to adopted standards and calculation methods.

A DoS describes what defect types may exist in the component(s) for which the qualification in question will apply. The defect description includes all defect types that might reasonably exist in the component and that need to be assessed. The defects to be included in the qualification are described as precisely as possible with regard to position, orientation and properties. For example: type, morphology, tilt and skew.

The DoS also states the inspection volume.

1.5 Procure accredited inspection body

The procurement of an accredited inspection body must be done in accordance with TH's normal procurement routines and in good time. If a review of the defect and structural integrity analysis is included in the procurement, an agreed schedule including follow-up must be created.

1.6 Review defect and structural integrity analysis

The defect and structural integrity analysis must be reviewed by an accredited inspection body (AK) in accordance with their technical instructions.

AK must issue a certificate for the review of the defect and structural integrity analysis.

1.7 Choose inspection method

Based on the object description and defect and structural integrity analysis (DoS), TH proposes a preliminary inspection method. Which method is most appropriate depends on defect type, inspection volume, location and accessibility of the inspection area etc. The definitive choice of inspection method is done when procuring an inspection laboratory.

1.8 Make an inventory of previous qualifications and test specimens

TH must investigate whether any previous qualifications and/or test specimens exist that can be used for the object in question.

When making an inventory of previous qualifications, the following qualification alternatives should be considered:

- New qualification
- Combination of existing and new qualification
- Extension of existing qualification.

A new qualification means that the inspection object's material, geometry, defects etc. differ so much from what has previously been qualified that the inspection system cannot be technically justified on the basis of previously performed qualifications.

A combination of existing and new qualification means that an existing qualification can be used, but the new inspection system cannot be fully technically justified, but must be supplemented in various ways.

Extending an existing qualification is when the changes needed can be technically justified.

1.9 Procure qualification body

The procurement of a qualification body (KO) must be done in accordance with TH's normal procurement routines and in good time. As part of the procurement, an agreed schedule including follow-up must be created.

It is advisable to divide the order up into stages linked to different phases of the qualification, so as to make follow-up of KO's work on the project easier.
Examples of these may include:

- Preparation and consultancy
- Review of technical justification and associated documentation
- Review of inspection procedure
- Practical demonstrations
- Subsequent work, final report, certificate etc.

KO must appoint an executive for each qualification task. This person will have full responsibility for the qualification on KO's behalf, with regard to technical content, planning and finance, and will be TH's sole contact.

1.10 Procure inspection company

The procurement of an inspection company (accredited laboratory, AL) must begin in good time. For complicated assignments, the procurement must be completed about two years before planned inspection.

The inspection assignment must be well defined and precisely described in detail in the request for tender, so that the inspection company is able to understand the assignment and present a relevant tender. The request must also state how the tender is to be structured so that it can be evaluated by the client.

Before or in connection with TH's preparation of the request for tender to AL, KO can assist with technical support and advice on TH's request.

It is important that all requirements and assumptions are described in the request for tender, so that prospective suppliers have what is needed to submit a tender. The request should include the following, for example:

- Defect types
- Defect orientation
- Detection target
- Qualification defect and requirement that AL states measurement uncertainties
- Critical component geometries
- Special requirements for inspection techniques
- Environmental effects
- MTO (man, technique, organisation) aspects.

Other requirements for the supplier that must be specified in the request are scope and level of technical reviews for technical justification and other data for which the supplier is expected to be responsible. The supplier must present a qualification strategy as an attachment to the tender, showing how stated requirements and assumptions are fulfilled.

Otherwise, the procurement of an AL should be performed according to TH's normal procurement routines.

1.11 Qualification documentation

The qualification documentation is a document in which TH describes the objective of the qualification and what KO must qualify the inspection procedure against. It is important that the documentation/objective for the qualification is defined as early as possible and is accepted by all parties involved.

In the documentation/objective, the following is normally determined:

- Type of qualification
- Qualification defect
- Detection target
- Characterisation requirement
- Tolerances for positioning
- Range within which sizing will occur
- Tolerances for sizing
- Inspection method(s)
- Scope of practical demonstrations
- Number and type of test specimens
- Mock-up requirement.

Some of the above points may need to be kept open until after the choice of inspection laboratory has been made.

The qualification documentation/objective is documented in a report which is reviewed according to normal routines. Documentation and objective can be included as part of the project description.

1.12 Start-up meeting

Every qualification begins with a start-up meeting at which the assumptions, qualification documentation of the qualification are presented.

1.13 Obtain test specimens

The information that forms the basis for determining the need for test specimens and their design comes from the work of verifying the inspection procedure. However, for planning and development reasons, the procurement of test specimens must often begin before the technical justification has been completed.
Depending on the situation, there may be a need for test specimens that simulate the component's geometry, material combinations and other component-specific properties or simpler test specimens where only individual parameters are verified.

A defect specification must be completed for the test specimen in question. This is based on the defect and structural integrity analysis and information from the technical justification of the inspection technique. Among other things, the defect specification includes type of defect, orientation, size distribution, number of defects and simulation technique. Both open and blind test specimens must have technical justifications of design and defect content.

For procedure qualification, open test specimens are used, i.e. where all information about implanted defects is known. Open test specimens are specified by AL/TH in terms of design and defect parameters. The data and defect specifications are reviewed by KO before manufacture begins.

Manufacture must follow a detailed manufacture and control plan. The manufacture and control plan must be reviewed and approved by TH and KO.

The control plan must as a minimum include the following:

- Control of material included
- Control of welded joints during and after manufacture
- Control of heat treatment
- Control during and after implanting of defects
- Delivery control.

For personnel and system qualification, blind test specimens are used, i.e. where only KO has information about implanted defects. These are specified by AL/TH with regard to design, but KO produces the defect specifications.

If the qualification includes both open and blind test specimens, it may be an advantage to charge KO with also producing defect specifications for the open specimens, so as to ensure compatibility between procedure and personnel qualifications.

A fingerprint must normally be made for every test specimen made, to ensure the quality of the test specimen. The fingerprint is intended as an assessment of whether the test specimen's defect simulation fulfils the defect specification and represents an as-built map before procedure and personnel qualifications take place.

The fingerprint must be produced in accordance with appropriate procedures with requirements for equipment, personnel competence and reporting. The procedure must be suited to the corresponding inspection of the object in the qualification in question. If test specimens are produced to previously qualified procedures, these should be followed for the fingerprint where appropriate.

A record must be written for each test specimen stating all defects reported with regard to signal response for detection, characterisation and determination of size. Where defects are not considered to fulfil the requirement in any of the cases, this must be clearly shown on the record.

When the fingerprint is completed, a meeting should be held between TH, AL and KO to report results and any deviations. This also applies to fingerprints for blind test specimens.

Fingerprints for blind test specimens should be made or monitored by KO, so as to ensure the secrecy of blind test specimens.

Test specimens are normally procured by TH.

2 Document NDT system

Normally the appointed accredited laboratory is responsible for ensuring that the activities in section 2 are performed in the way and to the quality specified in the procurement data.

2.1 Create inspection procedure

The inspection procedure is created by the appointed accredited laboratory (AL). The following conditions must be in place before an inspection procedure can be created:

- Anticipated defects must be identified
- An overall concept of how inspection is to be performed must be agreed with the client (TH)
- Information about the inspection area's geometry, material and other component information necessary for inspection
- MTO (man, technique, organisation) information that might affect test results must be identified.

Using this material as a basis, AL writes an inspection procedure. It is important to remember that an inspection procedure is an instruction to inspection personnel for the performance of the inspection. This must therefore be taken into consideration when formulating the procedure. The inspection procedure must thus describe the various parts of the inspection step by step in a clear manner. Parameters included must be stated with tolerances or ranges.

The information in the inspection procedure must be verified. This is done in a technical justification. It is important that all verification of the inspection procedure is reported in the technical justification and not written into the procedure itself.

2.2 Create technical justification (TM).

The technical justification (TM) refers to information that is reported in order to verify and justify the technical solution chosen to perform the defined inspection assignment.

A TM normally follows ENIQ Recommended Practice 2: ”Strategy and Recommended Contents for a Technical Justification”, issue 2, 2010, ENIQ report no.39, EUR 24111EN.

The TM must include information both about the component to be inspected and about the inspection technique/procedure including equipment. In the former, it may be about geometry, material, operating conditions etc., in the latter about technical inspection details, important variables, inspection tolerances etc.

The TM must include a measurement uncertainty analysis. The inspection system's influential/essential variables should normally be given in the TM according to the guidelines in Recommended Practice 1 “ENIQ Recommended Practice 1 – Influential/ Essential Parameters”, Issue 2, 2005, ENIQ Report no. 24, EUR 21751 EN.

An example of a technical justification is found in Enhagen 1, report 016/06, issue C.

A TM can consist of many different kinds of information, such as references to and quotations from the open literature, derivation of physical phenomena, mathematical modelling, results of experiments and investigations and reports of trials performed specifically for the procedure in question.

In the case of qualification of equipment against existing qualified procedures, a separate TM can be written for the equipment.

2.3 Review inspection procedure and technical justification (AL/TH)

The inspection procedure is the governing document for the inspection to be performed in the plant. Before qualification begins, it is therefore important that AL and TH ensure that it is appropriate for the purpose, complete and does not contain any technical inaccuracies.

AL must ensure that the procedure works by performing adequate analyses and practical tests. TH ensures that the inspection the procedure describes is suitable for the purpose with regard to the intended use in the plant and that its scope corresponds to what was ordered.
It is advisable for AL and TH to perform a final check on the inspection procedure, for example by means of a procedure acceptance test (PAT), so as to ensure the quality before qualification. Results of this check must be documented.

TH must review the TM with regard to technical quality and completeness.

3 Qualify NDT system

KO is responsible for ensuring that the activities in section 4 are performed and documented in such a way as to fulfil the requirements.

3.1 Review inspection procedure and technical justification (KO)

Inspection procedures and TM must be reviewed according to appropriate instructions, which must be so designed as to ensure reasonable similarity between different reviewers.

There must be close contact between KO and AL/TH during the review so that anything in the data that is unclear or incorrect can be rectified. KO's questions/comments and TH/AL's responses must always be documented. The results of the review must be documented and given to AL/TH.

3.2 Qualification procedure

In order to control the implementation of the qualification, KO, after reviewing the inspection procedure and TM, creates a qualification procedure.

The purpose of the qualification procedure is to give detailed instructions for how to perform the specific qualification. The qualification procedure must also state the assessment criteria for qualification and the scope of the practical demonstrations. This is done in accordance with KO's internal routines.

TH and AL must be given the opportunity to comment on the qualification procedure before the actual qualification commences.

3.3 Qualification meeting

The qualification meeting confirms that the previously stated assumptions and objective for the qualification still apply.

At this meeting AL/TH give a verbal presentation of the inspection procedure and technical justification.

KO gives a presentation of how it is intended that qualification will proceed in the case in question by going through its qualification procedure.

3.4 Qualify inspection equipment (including FAT)

If, after a review of TM has been performed, it is judged that practical demonstrations of carrier and control equipment need to be performed, these must occur under KO's leadership according to predetermined instructions and agreed qualifying procedure.

For this qualification of equipment, requirements are set for precision of positioning and repeatability. The equipment's stability and general suitability for the task is also assessed.

A programme for equipment qualification is normally prepared by AL and reviewed and approved by TH and KO. The equipment qualification is certified by KO.

The other requirements set by TH for the equipment, such as safety functions and FME, are checked as a factory acceptance test (FAT).

A programme for FAT is normally prepared by AL and reviewed and approved by TH. The equipment qualification is certified by TH.

Equipment qualification and FAT may be performed at the same time and according to a common programme.

Approved equipment qualification is documented in accordance with KO's routines and reported to TH and AL.

If equipment fails qualification, KO must call affected parties to a meeting to review the results and causes and decide on further action.

If FAT is completed without equipment qualification, responsibility passes to TH.

3.5 Qualify inspection procedure

If, after a review of TM has been performed, it is judged that practical demonstrations need to be performed, these must occur under KO's leadership according to predetermined instructions and an agreed qualifying procedure.

Approved qualification is documented in accordance with KO's routines and reported to TH and AL.

In the event of qualification failure, KO must call affected parties to a meeting to review the results and causes and decide on further action.

3.6 Qualify personnel

Qualification of personnel requires the existence of a qualified procedure and equipment. Practical trials for personnel qualification are normally carried out on blind test specimens. The qualification can apply separately to detection, characterisation, sizing, or all parts together.

It can be divided into four elements:

- Data collection
- Detection
- Characterisation
- Sizing.

The qualification may include individual elements or combinations.

Personnel may also be qualified through a technical justification.

Personnel who are to be qualified must be well prepared and trained for their respective tasks and if necessary certified.
In the case of qualification for manual inspection, the elements in the test may be included together or separately.

In the case of qualification for mechanised inspection that is performed as a single inspection, the tasks that need to be qualified must be defined and the requirements for each specified. Each individual is qualified for one or more specified tasks.

Defined MTO (man, technique, organisation) parameters in the qualification data that are of significance for the implementation of inspection must be taken into account when qualifying personnel.

Personnel who are to be qualified for data collection and assessment of inspection must be certified to at least level 2 according to ISO 9712 or another national standard with corresponding requirements. For other tasks with mechanised inspection, an assessment must be made regarding necessary basic personnel competence.

It is important for the result that the AL personnel who perform the practical demonstrations are very familiar with the inspection procedure and have been trained in the use of the associated inspection equipment.

Personnel qualification occurs under KO's leadership in accordance with predetermined instructions and the agreed qualifying procedure.

Approved qualification is documented in accordance with KO's routines and reported to TH and AL.

In the event of qualification failure, KO must call affected parties to a meeting to review the results, within the limits of what can be communicated in the light of the secrecy of blind tests.

Qualification certificates for personnel are valid for 5 calendar years.

3.7 Requalification

Requalification can become necessary for two reasons. Either personnel, procedures or equipment may have failed the qualification, or changes in the basis for qualification, equipment or procedures may call for an amendment of the qualification.

In the case of requalification because of a failure, the customer (TH and/or AL) must first show that appropriate measures have been taken to rectify the deficiencies that caused the failure.

Personnel who do not fulfil the stated requirements for one or more elements may only take a requalification during the course of one year.

In the case of requalification/amendment because of changes in the basis for qualification, equipment or procedures, the original qualification procedure is followed in relevant parts.

3.8 Reporting results

Results of qualification are reported by KO to the customer who has ordered the qualification, if not otherwise specifically stated in the order. Reports may also be provided to others by specific agreement. Reporting is done both verbally and in writing and must be as detailed and complete as possible, taking into account the requirement for secrecy of test specimens and their defect simulations.

Reporting to parties other than the orderer is an issue between the affected parties and not the responsibility of the qualification body.

The scope and validity of the qualification must be documented by KO.

Qualification of equipment and procedures has no time limit, provided there are no significant changes.

Personal qualifications have a time limit. The period of validity must appear in the documentation.

If reason arises to question an approved qualification, e.g. when the inspection purpose is not fulfilled when inspecting in the plant, KO must be notified with a written report and must then investigate the matter and propose whether the qualification certificate should be withdrawn. The affected AL and TH must be given the opportunity to comment before a decision is taken. The affected AL and TH must be notified in writing of a decision of certificate withdrawal. The decision must be properly justified.

4 Improve qualification process

If we are to succeed in improving qualification activities, it is important that experience and lessons learned are collected in a simple and effective way, so that possibilities for improvement can be identified.

4.1 Lessons learned

Addressing our experiences from qualification work is an effective way of improving the qualification process. Every qualification brings valuable new experience. Once a qualification project has been completed, the project manager (TH) calls a review meeting at which results, lessons learned and opinions from the parties involved are discussed. All involved parties, i.e. TH, AL and KO, should participate in this meeting.

The project manager summarises and evaluates the opinions and experiences presented and distributes these to those affected. Each involved party is responsible for making use of the lessons learned within its own organisation.

4.2 Inspection of object

After qualification is approved, inspections are performed in the plants.

4.3 Lessons learned after inspection

A further meeting between TH and AL is held in order to get feedback on how the qualified inspection system worked during inspection. KO can also be invited to this meeting if issues concerning qualification arose during the implementation of inspection. In this way lessons learned during inspection can be utilised.

4.4 Improve qualification process

In order to improve the process, lessons learned must be continuously documented and distributed to those affected by the qualification activities.

It is an important task of a forum such as THAG-ÅK to follow up on and inform about lessons that have been learned.

It is therefore the responsibility of members of THAG-ÅK, by means of various activities, to ensure that the lessons that have been learned are known and implemented. This can be done generally, such as through presentations at conferences, and also more directly, such as in FOP nuclear power.

5 Process description – chart