# PBM2 Appendix 1 Process Description

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# 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 main parts, as found in sections 1-4 of this document. Also see the overview of the process in figure 1 and section 5.

The activities included in the main group ”Qualify NDE System” (section 3) are not described in this document. For description of these activities, the SQC document “Qualify NDE System” is referred to, [3]. SQC is responsible for ensuring that the document reflects the current requirements on qualification. Alterations are communicated via THAG ÅK and the current edition shall be accessible on SQC’s website.

Note that this is the generally preferred order of the work flow. Certain activities may 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 the work flow should, in advance, be agreed between the parties involved.

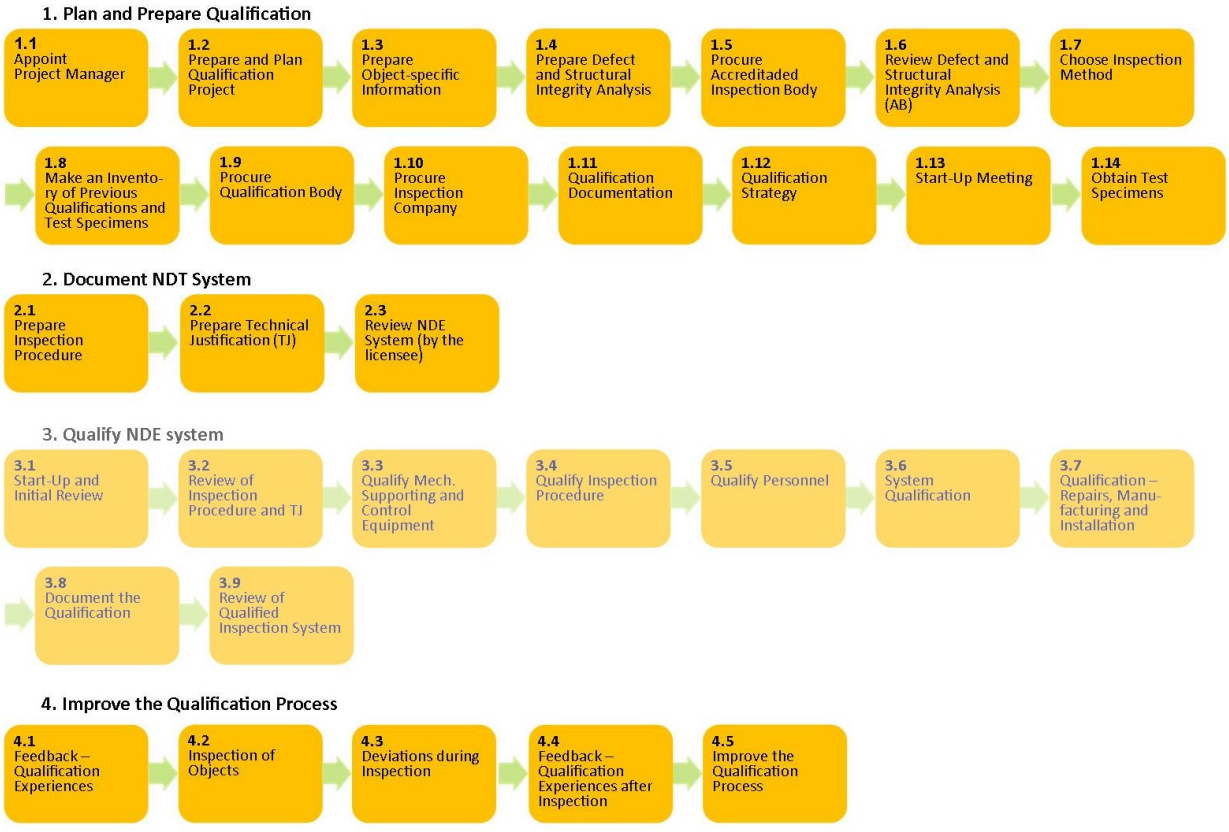


*Figure 1 Overview of the process chart*

# 1 Plan and Prepare Qualification

The licensee is generally responsible for planning and preparing qualifications.

## 1.1 Appoint the Licensee´s Project Manager

The licensee appoints a project manager, who must have the adequate education and training, experience and competence for this task. The project manager must also be assigned the required personnel resources and other aids, 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 finances). 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 shall continuously keep the parties involved informed of the progress of the work and ensure that all decisions taken are documented. The project manager shall also ensure that necessary decisions are made. All changes in the qualification project and other significant events must be documented. The project manager shall agree in writing any changes in the project's scope with all the parties concerned, and document them in a clear manner.

## 1.2 Prepare and Plan Qualification Project

### 1.2.1 Qualification data

Before a qualification project commences, the project manager must make sure that all input data and information required to start the project is available. The project manager must also ensure that the input data is quality assured.

Preparing a qualification project also involves producing object-specific information, necessary inspection requirements, time schedules and procurement documents for the qualification project. It is very important to have well defined inspection requirements, since these will be the basis on which further work is governed.

### 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 a qualification in an orderly fashion.

Generally, realistic detailed planning cannot be done until the licensee has ordered the accredited laboratory (AL). It is important, however, that the licensee as soon as possible forms an idea of the probable time required to complete a qualification project. Planning must be done before the qualification project begins and must be continuously reviewed by follow-up 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 limited and that interfaces with other sub-projects are clear.

### 1.2.3 Prepare a project description

Every qualification project shall have a project description produced by the project manager. The description shall include the information required to be able to perform the qualification project. Material produced during the preparation becomes the input data for the project. The project description shall also include a resource plan, which forms the basis for allocating resources to the project.

The project description is produced in order to clarify roles, quality assure and clarify the need for resources.

### 1.2.4 Follow-up

There shall be routines for following up finances, techniques, time and quality. Follow-up shall be performed regularly, and reviewed in relation to the plans for the project. All deviations from these plans shall be followed up and corrective measures taken. The project manager shall document all important events in the project.

Financial divergences shall be analysed and if possible rectified, as well as reported to those concerned.

### 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 shall clarify its purpose in advance. All meetings shall have an agenda, even though this may be very simple in many cases.

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

There shall be a routine for how the specific qualification project is to be continuously reported and with what frequency. It may be an advantage to specify which routine that will apply for fixed meeting dates 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 manufacturing 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 documentation
- 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 manufacturing 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 if and how heat treatment was performed
- Description of the surface (surface finish and surface undulations)
- Material certificate of materials included in the inspection object
- NDE records from prefabrication, assembly and in-service inspection
- Documented repairs and processing
- Documented deviations regarding dimensions, material thickness, internal and external geometrical variations, surface conditions
- Inspection conditions
- Ferrite content of austenitic castings.

Appropriate parts of the following MTO factors (man, technology, organisation) 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.

The object description may be prepared as a separate document or be included as part of the defect and structural integrity analysis.

## 1.4 Prepare 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 growth rate of defects under current operating conditions in the environment in question, resulting in the qualification defect size. Calculations are made for pre-determined 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 may reasonably exist in the component and that need to be assessed. The following information is required for the defects to be included in the qualification, with respect to position, orientation and properties.

- Defect types
- Defect location
- Defect orientation
- Tilt and skew of the defects
- Defect morphology (fine/rough surface, possible branching, defect width)
- Defect sizes of longitudinal and transverse defects with respect to height (depth) and length (acceptable defect size, qualification defect and detection target which shall be possible to detect, characterize and where applicable, sized).

The DoS also states the inspection volume.

## 1.5 Procure Accredited Inspection Body

The procurement of an accredited inspection body shall be done in accordance with the licensee's normal procurement procedures 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 shall be produced.

## 1.6 Review of Defect and Structural Integrity Analysis (AB)

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

A certificate of the review is issued by AB.

## 1.7 Choose Inspection Method

Based on the object description and defect and structural integrity analysis (DoS), the licensee 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 made in connection with the procurement of an inspection laboratory.

## 1.8 Make an Inventory of Previous Qualifications and Test Specimens

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

As an aid at the inventory, SQC’s databases for qualification certificates and test specimens can for instance be used. These are available on SQC’s website.

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 to such an extent in relation to what has previously been qualified that the inspection system cannot be technically justified on the basis of previously performed qualifications.

A combination of an existing and a new qualification means that an existing qualification can be used, but the new inspection system cannot be fully technically justified and needs to be supplemented in other respects.

Extension of an existing qualification can be performed when required changes can be technically justified.

## 1.9 Procure Qualification Body

Procurement of a qualification body (QB) shall take place in accordance with the licensee’s regular procurement procedures and be done in good time. The preliminary scope and time schedule shall be included in the procurement.

QB shall appoint a qualification manager for each qualification task. This person will have full responsibility for the qualification on QB's behalf, with regard to technical content, planning and finances, and will be the licensee´s main contact.

## 1.10 Procure Inspection Laboratory

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

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

Before or in connection with the licensee's preparation of the request for quotation to AL, QB can assist with technical support and advice on the licensee's request.

It is important that all requirements and conditions are described in the request for quotation, so that prospective suppliers know what is needed to submit a quotation. Hence, the request for quotation should for instance include the following information:

- Object description
- Defect description
- Detection target/qualification defect
- Tolerances for sizing
- Special requirements on inspection technique (characterization, positioning etc.)
- Special requirements on inspection equipment
- Requirements on qualification strategy
- Inspection scope

- Available test specimens
- MTO aspects
- Requirements on frequency of meetings and locations
- Requirements on the extent of shift work/working hours
- Frequency and routines for reporting of inspection results
- Requirements on accreditation, certification and third-party status
- Requirements on quality and environmental plan
- AL's prerequisites, i.e. transports, office areas, lifting operations, decontamination, impact on other work etc.

In addition to financial terms the quotation should as a minimum also include the following information:

- Description of the inspection system
- Presentation of information and requirements according to the request for quotation
- Qualification strategy (preliminary or final)
- References
- Project organisation
- Time schedule for qualification
- Time schedule for in service inspection including mobilisation, time by the object and demobilisation
- Preliminary estimation of inspection limitations
- Any risks and problems that may arise during the course of the project activities
- Clear presentation of any deviations in relation to the request for quotation.

In other respects, the procurement of an AL shall be performed in accordance with the licensee's general procurement procedures.

QB should review the qualification strategy and the time schedule before the procurement is concluded in order to assess the possibility to perform the qualification in question.

## 1.11 Qualification Documentation

The qualification documentation is a document in which the licensee summarizes and describes the objectives of the qualification and what requirements QB shall qualify the inspection procedure against. The qualification documentation may also be produced earlier in the process and form the basis of the procurement.

The qualification documentation is generally based on the following factors being determined:

- Type of qualification
- Detection target/qualification defect
- Tolerances for sizing
- Characterisation requirements
- Tolerances for positioning
- Sizing interval
- Inspection method(s)
- Extent of practical demonstrations
- Number and type of test specimens
- Mock-up needs.

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

## 1.12 Qualification Strategy

A qualification strategy presents how requirements and conditions are fulfilled and shall where applicable include the following information:

- Object description
- Requirements on the inspection system
- Description of the inspection system
- Description of the qualification strategy
- The need of test specimens and mock-up
- Proposal for procedure, personnel and equipment qualification
- Scope of technical justifications.

The qualification strategy is generally produced by AL, but may also be issued by the licensee.

## 1.13 Start-Up Meeting

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

The participants are generally the licensee, AL and QB.

The following subjects should be addressed at the meeting:

- Inspection object
- Qualification documentation
- Qualification strategy
- Time schedule
- Project organisation and contacts
- Experiences from previously performed qualifications and inspections.

## 1.14 Obtain Test Specimens

Test specimens are used within the qualification projects to develop technique and procedure, and for practical demonstrations with the aim to supplement and verify standpoints and justifications in the technical justification (TJ).

Open test specimens with known defect content are used for the development and qualification of procedures.

Blind test specimens with classified content are used for qualification of personnel and systems.

### 1.14.1 Manufacturing and quality assurance of test specimens

Manufacturers of test specimens must be assessed and approved by the licensee (audit). They must have a documented capacity to manufacture the types of simulations required to represent real defects. Test specimen manufacturers (TSM) shall work according to a quality assurance system which meets the requirements given in EN ISO 9001 or corresponding. Approved manufacturers are represented in the Defect Matrix, see report as per reference [9]. Manufacturing shall take place in accordance with a detailed manufacture and inspection plan which has been reviewed and approved by the licensee and QB.

The plan shall as a minimum include the following information:

- Quality control of the material included
- Welding and manufacturing procedure/-s which to the extent possible shall be identical to the ones used for the intended inspection object
- Inspection during and after manufacturing of weld joint
- Quality control of heat treatment
- Inspection during and after implanting of defects
- Delivery inspection.

The licensee shall perform an audit of manufacturers of test specimens to an adequate extent. QB shall be informed about such audits and be offered to take part.

Manufacturers must also have an approved non-disclosure agreement. Other organisations connected with test specimens (the licensee, AL and QB) must have a quality assurance system which ensures that classified information is handled accordingly and that confidential relations with personnel in these organisations are established to the adequate extent.

### 1.14.2 Defect specification and technical justification, test specimens

In the event the qualification includes practical demonstrations, QB is responsible for preparing defect specifications and TJ for blind test specimens intended for qualification of personnel. These documents are classified as secret.

Regarding the open test specimens for the procedure qualification, the licensee is generally responsible for the defect specification and the technical justification, TJ. However, as it is part of the qualification prerequisites, it shall be reviewed and approved by QB.

At the request of the licensee, QB can also prepare defect specifications including associated TJ, for the open test specimens.

### 1.14.3 Design of test specimens

Test specimens must be designed to be an adequate simulation of the objects they are intended to simulate. Prior to qualification, the requirements on the test specimen shall be assessed based on the inspection system and the inspection object. Important dimensions affecting accessibility and measurement uncertainty shall be checked in consultation with the licensee, AL och TSM. Defects shall be simulated with the same technique in open as well as in blind test specimens and in other respects represent an equal inspection challenge.

As a guide-line during the choice of test specimen manufacturer and the defect simulations which the respective manufacturers have a documented capacity to manufacture, the Defect Matrix is used; see report as per reference [9].

### 1.14.4 Fingerprint

A fingerprint (FP) must generally be performed for every manufactured test specimen, 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. The fingerprint is the quality assurance of the test specimen before procedure and personnel qualifications. The FP is also intended as an assessment of the relevance in signal responses from defect simulations versus the defect types they are intended to represent. This entails that FP should be performed by the use of the NDE method intended for the qualification and inspection of the inspection object in question.

FP should to the extent possible use the intended inspection technique.

FP for open test specimens is performed by AL or QB. FP for blind test specimens shall be performed or monitored by QB in order to ensure the secrecy concerning blind test specimens.

Test specimen documentation is archived in a test specimen binder as well as in the test specimen data base.

# 2 Document NDE System

Generally, the appointed accredited laboratory is responsible for ensuring that the activities in section 2 are performed in the way, and with the quality specified in the procurement documentation.

The NDE system includes procedure, personnel and inspection equipment.

In order to be able to *prepare an inspection procedure and document an NDE system*, the following conditions must be in place:

- Anticipated defects shall be identified
- An overall concept of how inspection is to be performed shall be agreed with the client (the licensee)
- Information about the inspection area’s geometry, material and other component information necessary for the inspection
- MTO information that may affect the inspection result shall be identified.

## 2.1 Prepare Inspection Procedure

The inspection procedure is prepared by the appointed accredited laboratory (AL).

It is important to remember that an inspection procedure is an instruction for inspection personnel how to perform an inspection. This must therefore be taken into consideration when preparing the procedure. The inspection procedure shall be unambiguous and systematically designed to ensure that the result is reproduced irrespective of which operator that is using it. Parameters included shall be stated with tolerances or ranges.

A procedure shall as a minimum include the following information:

- Inspection object and scope
- Defect types
- References, such as TJ and equipment manuals
- Certification and qualification requirements for personnel
- Equipment description
- Calibration and verification description
- Description of data acquisition
- Description of evaluation
- Reporting requirements.

The information given in the inspection procedure must be justified, which is done in a technical justification.

## 2.2 Prepare Technical Justification (TJ)

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

A technical justification (TJ) shall generally comply with ENIQ Recommended Practice 2 ”Strategy and Recommended Contents for a Technical Justification” [6].

The TJ shall include information about the component to be inspected as well as information about the inspection technique/procedure including the manipulator. In the former, this may refer to geometry, material, operating conditions and etc., and in the latter this may refer to technical inspection details, important/essential variables, inspection tolerances etc.

The TJ must include a measurement uncertainty analysis. As a tool, the software UINDT may for instance be used.

The inspection system's important/essential variables should generally be given in the TJ in accordance with the guidelines stated in the Recommended Practice 1 "ENIQ Recommended Practice 1 - Influential/ Essential Parameters" [7]. An example of a TJ is given in Enhagen 1 [8].

A TJ may 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 analyses and reports of trials performed specifically for the inspection procedure in question.

TJ for control system and manipulator may be issued separately or be included in the TJ of the complete NDE system.

## 2.3 Review NDE System (by the licensee)

The licensee shall thoroughly review the inspection procedure and the TJ in accordance with the following points:

– Is the inspection procedure unambiguous and systematically designed and does it contain the information required to perform and document the inspection correctly?

– Does the TJ contain the information required and is the information described to an adequate extent?

– Does the inspection procedure and the TJ meet the requirements and are they considered approved for being submitted to QB for review?

It is advisable for AL and the licensee to perform a final check of the inspection procedure, for instance by means of a Procedure Acceptance Test (PAT), in order to ensure the quality before the qualification.

PAT is to be performed in accordance with a predetermined programme. The results of the PAT must be documented.

Control system and manipulator shall generally be demonstrated to the licensee in a Factory Acceptance Test (FAT). This is generally performed in connection with equipment qualification, see section 3. FAT programmes are issued by AL. A FAT includes for instance demonstration of safety functions, FME/clean system and other requirements from the licensee not included in the equipment qualification.

# 3 Qualify NDE System

Qualification of NDE systems is not described in this document. A description of these activities is found in the SQC document ”Qualify NDE system” [3]. SQC is responsible for ensuring that the document reflects valid requirement for qualification. Alterations are to be communicated via THAG ÅK and the valid edition shall be accessible on SQC’s website.

# 4 Improve the 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 Feedback - Qualification Experiences

Addressing experience from qualification activities is an effective way of improving the qualification process. Every qualification brings valuable new experiences. Once a qualification project has been completed, the project manager (from the licensee) invites to a lessons learn meeting at which results, experiences gained, and opinions from the parties involved are discussed. All the parties involved, i.e. the licensee, AL and QB, should participate in this meeting.

All the main stages included in the qualification in question shall be discussed at the meeting. Proposal for the agenda;

- Qualification documents from the licensee
- AL qualification strategy
- Test specimens
- The licensee’s review of Procedure and TJ (incl. PAT).
- QB’s review of Procedure and TJ
- Procedure qualification
- Equipment qualification and FAT
- Personnel qualification
- QB’s final documentation.

With respect to the above mentioned main stages as per the agenda, the following points should, where applicable, be taken into consideration;

- Was the stage performed as planned or not?
- Did the produced documentation have the expected quality?
- Was the agreed time schedule complied with?

Any deviations shall be accounted for and, if possible, proposals for measures to be taken shall be given.

Opinions and experiences presented are documented in writing and distributed to the parties concerned. The parties involved are each responsible for making use of gained experiences within their own organisations.

## 4.2 Inspection of Object

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

## 4.3 Deviations during Inspection

Deviations during inspection must be reported in the form of a non-conformity report including proposals for measures to be taken. Deviations with respect to the qualified inspection technique are assessed by QB and deviations with respect to the inspection limitations are assessed by AB.

### 4.3.1 Technical deviations

In the event of technical deviations (procedure, personnel and equipment) AL submits a deviation report to the licensee for review and further handling. The non-conformity report shall as a minimum include the following:

– Object
– Procedure
– Type of deviation
– Cause of deviation
– Measures and reason for measures
– Final assessment.

The non-conformity report is assessed and reviewed by QB whether or not supplementary qualification with respect to procedure, personnel and equipment is required, or if the inspection performed may still be considered adequate. AB shall make sure that the deviation has been reviewed by QB before the Certificate of Conformity is issued (“IOÖ”).

### 4.3.2 Inspection limitations

In the event of inspection limitations which are not already described in the procedure or inspection plan, AL shall submit a non-conformity report to the licensee for review and further handling. The non-conformity report shall as a minimum include the following:

- Object
- Procedure
- Cause of inspection limitations
- Extent of inspection limitations
- Measures
- Final assessment.

AB reviews and assesses the non-conformity.

## 4.4 Feedback – Qualification Experiences after Inspection

In order to have feedback on how the qualified inspection system worked during the inspection, an experience exchange meeting is held between the licensee and AL. QB may also be invited to this meeting if any issues concerning the qualification arose during the inspection. In this way experiences gained during inspection can be used in the future.

Opinions and experiences presented are documented in writing and distributed to the parties concerned. The parties involved are each responsible for making use of gained experiences within their own organisations.

## 4.5 Improve the Qualification Process

In order to improve the process, experiences gained must be continuously documented and distributed to those concerned by the qualification activities.

It is an important task of a forum such as THAG-ÅK to follow up on and inform about experiences gained.

It is therefore the responsibility of the members of THAG-ÅK, by means of various activities, to ensure that experiences gained become known and implemented. This can be done in general such as by presentations at conferences, and also more directly, such as in FOP nuclear power.

# 5 Process Description – Flow chart