



ENIQ RECOMMENDED PRACTICE

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Strategy and Recommended Contents for Inspection Procedures

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FOREWORD

This is the first issue of ENIQ Recommended Practice 12 (RP12). It was developed within the project GUSIP.

EXECUTIVE SUMMARY

This Recommended Practice (RP) has been developed as a consensus document amongst the members of NUGENIA Technical Area 8 (TA8) - ENIQ. The main objective of this RP is to support licensees, qualification bodies and inspection vendors to produce and assess an inspection procedure. The document includes what and how the contents in an inspection procedure should be described. The appendices give examples on the content of different types of inspection procedures.

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1 Introduction

The European Methodology Document [1] is intended to provide a general framework for the development of qualifications for the inspection of specific components to ensure they are developed in a coherent and consistent way while still allowing qualification to be tailored in detail to meet different national requirements.

This ENIQ Recommended Practice (RP) will assist those involved in inspection qualifications in how to prepare, use and apply an inspection procedure (IP) in agreement with the spirit of the European methodology. This RP is relevant to any non-destructive testing (NDT) method.

2 Objectives

The main objectives of this RP are:

- Identify the content that should be included in an IP;
- Promote the harmonisation of practices and the transferability of qualifications between organisations and countries by defining a uniform format for IP documents.
- To provide guidance on how to write user friendly IPs.

The general definitions in the ENIQ Glossary [2] apply to this RP.

Note: It is intended that this RP should be relevant for any NDT method. However, because the area in which qualification has most frequently been applied is the ultrasonic testing (UT) method, where examples are given. These are generally drawn from UT applications. Also it should be emphasised that although this particular document was originally developed specifically for in-service inspection (ISI) of nuclear power plant (NPP) components, the principles given in it can be used for qualification of manufacturing inspections or for inspections performed in the non-nuclear field.

3 Concept and use of an IP

The IP is a document prepared by the appointed (or approved or accredited) inspection body. IPs are controlling documents that must describe in detail the application of a qualified inspection and provide assurance that the inspection has been applied correctly.

It is important to remember that an IP is an instruction for inspection personnel, or inspectors, on how to perform an inspection. This must therefore be taken into consideration when preparing the IP. The IP should be systematically designed and unambiguous to ensure that the result is reproduced irrespective of which inspector applies it. It is important that all essential parameters are adequately controlled, therefore essential parameters should be stated with associated tolerances or ranges.

The IP should be a standalone document and refer to other documents of the qualification dossier, but sparingly (TJ, training dossier, etc.).

4 Procedure Usability and Adherence Principles

A good IP must adequately control the application of the inspection but should be presented in a manner which promotes usability for the operator and adherence.

4.1 Adherence Principles

Procedure adherence means understanding a procedure's purpose, scope, and intent and following its direction. The user performs all actions as written and in the sequence specified by the procedure.

However, if the procedure cannot be used as written, then the activity should be stopped and the issue must be resolved before the user continues.

Do not forget that:

- A procedure must not overcome incompetence but complete know-how;
- A procedure must be legible, understandable and contain only relevant information (avoid convoluted sentences that do not contribute to the inspection).

The procedure should be written in a systematic way and contain the information needed to perform the inspection as intended. The steps in the procedure must not be ambiguous or open to interpretation depending on the person using the procedure.

4.2 Procedure Usability

In order for it to fulfil its purpose and guide the inspector towards a successful completion of the inspection task, the procedure needs not only to contain all the relevant information, but also communicate the information in a way which allows the inspector to conduct the task effectively and efficiently. The effectiveness of the IP in ensuring that the inspection is applied in accordance with the intent of the inspection design is partly dependent on the usability of the IP and the familiarity of data presentation to inspectors. Users of IPs commonly face three types of problems:

- The ease with which information can be located within the procedure;
- Understanding the information presented in multiple formats (text, tables and images);
- Inconsistent presentation of information.

These factors should be considered at the beginning of IP development and borne in mind throughout.

The IP, as one of the most important tools in NDT, is an important example of a measure designed to prevent failures occurring because insufficient attention has been given to human factors. Recent initiatives in this field of study [3][4] suggest that careful consideration of the understandability of the content and the formatting of the procedure may result in a procedure that is more likely to be used, understood and applied consistently and efficiently. For that purpose, it is highly recommended that:

- Procedures are developed with human factor principles in mind. The IP is an ordered succession of specifications describing in a detailed, sequential and identifiable manner the various decision-making stages leading to the final result, irrespective of the parties involved.
- Some of the personnel that is going to use the procedure is involved in the development of the procedure. Writing a procedure containing clear instructions is not enough. The content must also be compatible with the actual work of the inspector. The execution order of the instructions in the IP is not enough by itself to make a written procedure "intelligible". Studies have shown the need to segment command processing into three temporally distinct periods approximating: reading, understanding and execution of instructions. For this reason, it is important, after specific training, that the inspectors responsible for the implementation of the procedure have the opportunity to test the NDT system (including the IP) before submitting it to the qualification body (QB).
- The procedure is updated as necessary following experience of applying the procedure.

5 General recommendations for the Layout of an Inspection Procedure

This section provides tools, techniques, and an overall style for procedure writing. Procedures written in this manner will enable qualified inspectors to successfully perform a task in a consistent manner.

5.1 Procedure Designation

The procedure designation should enable the end-user to determine that the correct procedure has been obtained for the task to be performed. The numbering should be unique and logical and it is recommended that the system should include information such as plant/unit identification and NDT discipline (e.g. UT).

5.2 General Layout and Fonts

The physical presentation of the procedure should be appropriate for the application. For example, a normal paper format (e.g. A4) would probably be appropriate for use by inspectors that apply a manual inspection in a confined space.

The following specifications are recommended:

- Ensure that the text size is large enough for users to read the procedure at all anticipated distances and lighting conditions;
- Use only one font type within the body of the procedure. However, supplemental information may use a different font type, style, formatting, or letter size to improve procedure usability by distinguishing between instructions and supplemental information;
- A4 paper, white and in portrait orientation;
- Establish standard margins such that if the procedure is copied or hole-punched, information is not lost even if double-sided;
- Establish a standard font type and size (e.g. Arial 11 or 12, or Times New Roman 12) for all procedures that is readable.

5.3 Page Headers and Footers

Headers and footers should principally be used to display information to identify the document. A standardised header and/or footer should be included on each page of the IP, including all appendices or attachment pages. It is recommended that the header/footer contain the following:

- Procedure title;
- Procedure number;
- Issue or revision number;
- A consecutive page number and total page count formatted as “Page X of Y” for the main body of the IP;
- A separate consecutive appendix page numbering system, if desired;
- Supplemental information, e.g. record retention information or form numbers.

5.4 Text and Page layout

Text and page layout makes a significant contribution to readability. The following guidelines are suggested:

- Consider using single line spacing;

- Separate steps/instructions by at least one line of white space, as it improves the readability of a procedure;
- Left justify all sections and working step text;
- Make only one action per step;
- Adjust the placement of sentences and steps such that they are maintained unbroken and on the same page. When the content of a step or sub-step continues onto another page, a continuation heading should be used;
- Provide a consistent step numbering scheme for all procedures. Step numbering schemes should differentiate between steps and sub-steps of the procedure by providing identifiable differences from one level or step level to the next. Limit numbered steps to a small number of levels, e.g. four levels of detail.

5.5 Worked Examples

As discussed in Section 4, the way used to communicate information can have a significant impact on the usability of an IP. This subsection includes some examples approaches that were appraised by inspectors.

Text format and font can be used to distinguish instructions that can be interpreted differently. For example, alphanumeric step numbering can be used for steps to be performed in the order written and bulleted steps used within a single alphanumeric step for steps that can be performed in any order, prior to proceeding to next alphanumeric step. The IP should be clear in any formatting used to identify differences in how the IP can be applied. See Figure 1 for a worked example.

Make only one action per step and write the text in an active language. For example:

- Load the setup file NDE350_Scan_1A;
- Load the setup files in the order listed in Table 1.

General wording like “load the appropriate setup file” should be avoided.

It is usually necessary to include guidance or background material within the procedure that do not form part of the procedure steps. This information should be clearly distinguishable from procedural steps using a consistently applied label. For example, where a procedural step number would normally appear the text could be marked as a “NOTE”. See Figure 1 for an example.

Site 3, Unit 2 Pressuriser Surge Line Weld Inspection	NDE350 UT Issue 3
<u>Section F. Procedural Steps</u>	
<u>F1 Establish Datum Positions</u>	
F1.1	Check that lagging has been removed from the pipework up to an axial distance of at least 400 mm in both directions from the edges of the weld cap for both welds.
NOTE	<i>If necessary Figure A1 can be consulted to locate the correct welds.</i>
F1.2	Establish the axial datum location on both welds by visually locating the weld toe on both sides of the weld centreline at the 12 o'clock circumferential position, using an approved marker from the equipment list. <ul style="list-style-type: none"> • Mark the axial datum on weld W1 • Mark the axial datum on weld W2
NOTE	<i>The axial datum is defined as the location halfway between the two weld toes.</i>
NOTE	<i>The circumferential datum should already be marked on the welds via a vibro-etched line.</i>
F1.3	If necessary an approved marker pen can be used to mark the circumferential datum position at the 12 o'clock position: <ul style="list-style-type: none"> • Mark the circumferential datum on weld W1 • Mark the circumferential datum on weld W2
Retention class A	Page 5 of 76

Figure 1: An example extract from an IP

6 General Recommendations for the Content of an Inspection Procedure

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

The procedure should include, as appropriate, according to the TJ, all relevant data relating to the equipment identity, essential parameters, evaluation criteria, specific requirements for personnel competence, responsibilities, assessment criteria, calibration blocks, input parameter, detection target, sizing, tolerances etc.

In general, all parameters must be described so that it can be read in which limits the procedure applies.

The following describe what chapters would normally be expected in an IP. The requirement for the content of each section can be found in Appendix 1.

- Revision of the procedure;
- Scope and purpose;

- References;
- Organisation and personnel;
- Precautions and limitations for the inspection;
- Prerequisites;
- Object description;
- Equipment list;
- Inspection instructions;
- Equipment calibration and essential parameter checks;
- Data acquisition;
- Evaluation;
- Reporting and recording;
- Revisions of the procedure;
- Appendices and attachments.

REFERENCES

- [1] *The European Methodology for Qualification of Non-Destructive Testing - Issue 4*, ENIQ Report no. 61, The NUGENIA Association, 2019.
- [2] *ENIQ Glossary of Terms – Issue 3*, ENIQ Report no. 62, The NUGENIA Association, 2019.
- [3] *WANO Procedure Use & Adherence*, WANO GP ATL-10-002, World Association of Nuclear Operators (WANO), 2010.
- [4] McGrath, B., *Programme for the Assessment of NDT in Industry, PANI 3*, research report no. 617, Serco Assurance, 2008.
- [5] *ENIQ Recommended Practice 2: Strategy and Recommended Contents for Technical Justifications - Issue 3*, ENIQ Report no. 54, The NUGENIA Association, 2018.
- [6] *ENIQ position on Guidance on the Specification of Input Parameters to Inspection and Inspection Qualification Requirements*, ENIQ report no. 50, The NUGENIA Association, 2014.

APPENDICES

Appendix 1: Content of an Inspection Procedure

This appendix details the major recommended content of a IP. Whilst reading this material it should be borne in mind that the exact composition of an IP has to be tailor-made depending on the techniques used.

Section 1: Scope and Purpose (brief description)

A short summary should be given explaining the purpose of the IP. This section should describe the activities covered by the procedure and, if necessary, any limitations or boundaries of the procedure should be stated. Provide an introduction to and outline description of the inspection including components to be inspected, inspection volume the defect types including detection target, sizing tolerances sought and inspection methods to be applied.

Section 2: References (underlying documents)

The reference section should identify the documents used in the development of the procedure or required for procedure performance.

- Drawings and reference documents;
- Equipment manuals;
- Cross-references to other procedures included in the overall inspection;
- TJ;
- Inspection datasheet (input data) relevant to the qualification (see also [6]).

Section 3: Personnel

This section should describe personnel requirements including:

- Different roles;
- Training;
- Experience:
- Certifications level:
- etc

Section 4: Precautions and Limitations of the inspection

This section may be split into subchapters for precautions and for limitations.

Include precautions to alert the procedure user to those measures that protect equipment, personnel from abnormal situations. Precautions generally apply to the entire procedure.

Include limitations to the performance of instructions section steps or sections.

- Limitation statements describe regulatory or site administrative limits that the procedure is bound by;
- If limitations are required, then provide specific limits on parameters being controlled and the appropriate corrective measures.

Be aware of the following when evaluating precautions and limitations:

- Radiation or contamination;
- High temperature or high pressure fluids;
- Dangerous chemical or hazardous materials;
- Air quality concerns;
- Electrical shock;
- High noise levels;
- Confined space hazards;
- Moving equipment;
- Fire hazards.

Section 5: Prerequisites

All those essential parameters that have been defined and justified should be checked before inspection start, e.g. surface condition, cleanliness, temperature, accessibility, marking, identification of welds. If the description is too large, specific documents can be produced and their references added to the main procedure. These actions are generally the responsibility of the licensee and/or supplier, but should be verified before inspection.

Identification and verifications of all equipment and consumables to be used are within their test conformity (or calibration) dates.

Prerequisites should also identify the activities to be completed by the inspector and requirements that should be met prior to procedure application, such as system setup and apparatus settings (if needed add subchapter).

Object description

A short overview of the objectives of the IP should be provided:

- Object, material compositions, weld type, dimensions, thickness, radii, etc.;
- Inspection technique, detection, characterization, sizing;
- Defect types, orientation of defects, tilt of defects, size of defects, etc.;
- Geometries;
- Requirements on surfaces (flatness, smoothness, weld reinforcement etc.);
- Temperature;
- Requirements for purity (coating, spays etc.);
- Accessibility (presentation of any known inspection restrictions).

Equipment list

Depending on the technique used the equipment list could contain e.g.

- Manipulator main characteristics;
- Instrumentation, type, etc.;
- Acquisition systems, software, version, etc.;
- Analysis system, software, version, etc.;
- Probes main characteristics, coil size, type, frequency, etc.;

- Camera;
- Other relevant information, e.g. couplant, etc.;
- Cables main characteristics, impedance, length connectors, etc;
- Reference/calibration objects.

Section 6: Inspection Procedure

This section should contain the instructions to be followed by inspectors to apply the inspection. It can be divided in subchapters separating the steps covering data acquisition and evaluation. The format and style recommended for the instructions is covered in Section 5 of the main content of this RP.

The properties of the NDT equipment and products used, the setting, calibration and verification conditions, usage conditions and implementation procedure should be specified.

The steps must clearly specify what the acceptable changes in key parameters are, e.g. for the NDT equipment. The limits of these key parameters must be shown in the procedure and enable a significant change in an indication to be assessed. It is also important to state what to do if something is outside of the specifications.

Equipment calibration and essential parameter checks

This chapter should contain the system setup, including the instrumentation settings, reference reflectors. This information is commonly included in an appendix to the IP. All the different parts can be separate subchapters.

Those essential parameters that can vary and have been defined in the TJ [5], with a tolerance, should be part of the calibration section in the IP, and to be checked before, during and after inspection performance. It is recommended that a complete list of essential parameters is included in a table that lists the nominal value of each parameter and the relevant tolerance for the qualification. The table should also contain a space for operators to record the value of each essential parameter at the start and end of the inspection, and a signature block to allow the inspection leader (or equivalent) to sign the table when all checks have been completed. The main body of the IP should contain an instruction to complete the table at the appropriate points throughout the inspection to ensure that all parameters have been checked at the start of the inspection and re-checked at completion.

The performance of the calibration should be described in a way that avoids mistakes and personal interpretation of the way to calibrate the NDT system. All setups, calibration block, reflector etc. should be clearly described. Normally the following areas would be covered:

- System setup;
- Apparatus settings;
- Periodic check;
- System calibration;
- Basic calibration;
- Calibration check and reflectors identification used for the calibration;
- Essential parameters that have to be checked.

For each parameter set checked during calibration, information must be included on both acceptance requirements and actions to be performed if the criteria are not fulfilled.

Data acquisition

The performance of the data acquisition should be described in a way that avoids mistakes and personal interpretation of the way to collect data with the NDT system. All steps necessary to perform the data acquisition should be clearly listed in order of performance. Those steps should at least contain:

- Reference point;
- Co-ordinate system;
- Scanning pattern/steps;
- Max. scanning speed;
- Inspection volume;
- Scanning area;
- End effector position (Probe, camera and/or measuring device);
- Acquisition software configuration (display, channels, signals...to be monitored);
- File name.

The proceedings on how to verify that the quality of the data is OK and that the entire inspection volume is covered, e.g. quality acceptance criteria, are specified and are checked by the inspector using the software accordingly:

- level of noise;
- coupling check criteria;
- missing line;
- saturation.

Evaluation

The methodology and order used to evaluate the data must be in a way that avoids mistakes and personal interpretation of the way to analyse data. It should clearly describe settings and reporting criteria, and describe how the indication patterns are evaluated and characterised. The following topics would normally be covered:

- Description of detection / reporting level criteria(s) (quantitative value: amplitude, phase, SNR, length,...);
- Positioning of defects;
- Description of criteria for characterisation;
 - Orientation;
 - surface breaking;
 - embedded;
 - volumetric;
 - planar;
- Description of sizing and criteria;
- Tolerances that should be taken into account when positioning and sizing indications;
- How to treat reportable indications located outside of the inspection volume;

- Which parameters to measure and record for the inspection report.

Configuration of the software analysis is described regarding display, channels, size of windows, signals that are to be used from the inspector to lead the analysis step-by-step. This ensures that the use and the configuration of the software is not dependant on the inspector.

Use of a specific chart-flow is recommended for the evaluation and analyse of the data. Examples of an evaluation section from an IP and associated flowcharts are shown in Figures 2 and 3.

6.3 Evaluation

The main stages of data evaluation are listed below:

1. Data Quality:
Verification of data quality to ensure integrity of the inspection results. (Ch 6.3.2)
2. Evaluation of ET detection data for ID defects: (Ch 6.3.3)
3. Evaluation of UT detection data for embedded defects: (Ch 6.3.4)
Detection is performed with the 55°TRL fd10.
4. Characterisation (Inner Surface Breaking / Embedded):
Characterisation between inner surface breaking and embedded will be performed using ET. (Ch 6.3.5.1)
5. Characterisation (Planar / Volumetric)
0°TRL distinguishes between planar and volumetric indications. (Ch 6.3.5.2)
6. Length Sizing:
Length sizing of ID defects is performed using ET. (Ch 6.3.6.1)
Length sizing of embedded defects is performed using the 55°TRL detection probe. (Ch 6.3.6.2)
7. Height Sizing: (Ch 6.3.7)
Height sizing is performed for both surface breaking and embedded planar defects.
Height of ID surface breaking defects is measured to the bottom tip.
Height of embedded defects is measured between the top and bottom tip.
8. Ligament Sizing:
Ligaments are only required to be measured for embedded flaws. The distance between the upper tip and the inner surface shall be measured.

See flowchart in appendix 2 show the evaluation step.

Note: The flowchart needs to be followed for each indication individually.

6.3.1 Requirements for the Data Evaluator

The data evaluator shall have access to all documentation necessary for the inspection, such as procedure, technical justification, object drawings, scan instruction, scan file list, calibration protocols, previous inspection results, etc. Direct communication with the data collector is also a requirement.

The evaluation process shall be recorded on the Defect Record Form (Appendix 5).

 (Ctrl) ▾

Figure 2: An example extract from the evaluation section of an IP

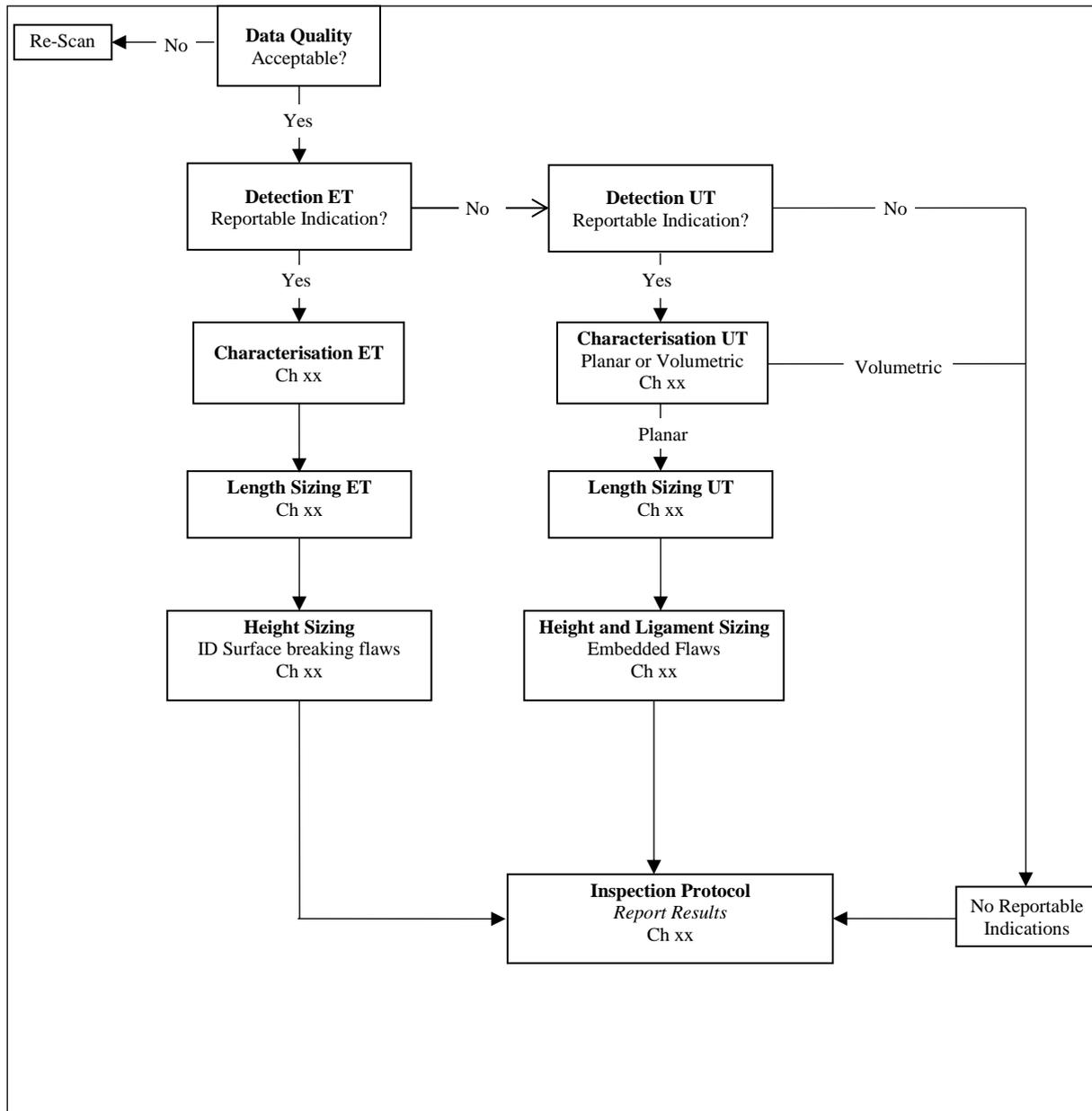


Figure 3: An example flow chart from the evaluation section of an IP

Section 7: Reporting and Recording

This section should clearly identify only those records generated as a result of the performance of the procedure, and reference certificates and other important documents.

The chapter should describe what and how the reporting should be performed. The examination (or inspection) report and appendices should contain at the least the following items:

- Document identity including revision;
- Date, location, signature;
- Component identity;
- Component description including geometry, material and expected limitations;
- Procedure and qualification certificate;
- Personnel (position and NDT-competences) and qualification certificates;

- Manipulator and qualification certificates;
- Inspection equipment and qualification certificates;
- Actual conditions for adjusting NDT apparatus;
- Probes and connectors;
- Calibration results;
- Reporting requirements (depth/length ratio);
- Reporting level and tolerances;
- Inspection results including:
 - Inspection restrictions (if any);
 - Information about detected reportable indications: type, length, height, position;
 - Essential parameter list;¹⁾
- Non-conformity process;²⁾
- Appendices (if any)³⁾ and/or other related documentation.

Remarks:

¹⁾ In many cases a list of essential parameters could be included with the expected values and their range of variation and the measured values. Alternatively the information could be recorded in a log book produced during the inspection and appropriately archived and referenced in the inspection report.

²⁾ A subchapter on how to treat deviations and non-conformities can be written depending on the requirement of the NPP and QB.

³⁾ It is very important that all appendices and other related documents are linked (report id nr, number of pages, etc.) to the report.

Section 8: Revision of the Procedure

Provide a clear and simple means of identifying the alterations (additions, corrections, or deletions) of the procedure. Revision bars and the summary of alterations remain until the next procedure revision.

Section 9: Appendices and Attachments

The appendices section is optional but it should always be the last section in the procedure. Each appendix should include:

- Uniquely identified by title and attachment identifier;
- Ordered with a sequential identifier;
- Displayed using the unique attachment page number and total attachment;
- page count;
- Referenced within the body of the procedure.

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ABOUT NUGENIA AND ENIQ

NUGENIA is an international non-profit association under Belgian law established in 2011. Dedicated to the research and development of nuclear fission technologies, with a focus on Generation II & III nuclear plants, it provides scientific and technical basis to the community by initiating and supporting international R&D projects and programmes. The Association gathers member organisations from industry, research, safety organisations and academia.

The activities of NUGENIA cover plant safety & risk assessment, severe accidents, reactor operation, integrity assessment and ageing of systems, structures & components, development of fuel, waste & spent fuel management & reactor decommissioning, innovative light water reactor design & technologies, harmonisation and in-service inspection & their qualification.

The European Network for Inspection and Qualification (ENIQ) is a utility driven network working mainly in the areas of qualification of non-destructive testing (NDT) systems and risk-informed in-service inspection for nuclear power plants. Since its establishment in 1992 ENIQ has issued over 60 documents. Among them are the “European Methodology for Qualification of Non-Destructive Testing” and the “European Framework Document for Risk-Informed In-Service Inspection”. ENIQ is recognised as one of the main contributors to today’s global qualification guidelines for in-service inspection. ENIQ became Technical Area 8 of NUGENIA in 2012.

