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STANDARD REQUIREMENTS FOR THE DEVELOPMENT OF TERMS OF REFERENCE, TESTS AND TERMS OF USE OF OPERATIONAL NON DESTRUCTIVE TESTING TOOLS AND METHODS ON NUCLEAR FACILITIES

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RD EO 0487 - 05

STANDARD REQUIREMENTS FOR THE DEVELOPMENT OF TERMS OF REFERENCE, TESTS AND TERMS OF USE OF OPERATIONAL NON DESTRUCTIVE TESTING TOOLS AND METHODS ON NUCLEAR FACILITIES

These "Standard requirements for the development of terms of reference, tests and terms of use of service inspection/non destructive testing tools and methods on nuclear facilities" (hereinafter - the standard requirements) define the method of development of terms of reference, tests and terms of use of service inspection/non destructive testing tools and methods on nuclear facilities, being under construction, in use or being decommissioned on the territory of the Russian Federation.

Replace RD EO 0487-03 "Standard requirements for the development of terms of reference, tests and terms of use of service inspection/non destructive testing tools and methods on nuclear facilities".

Standard requirements developed by JSC "NIKIET" and "Rosenergoatom".

Content

Terms and definitions

Certification of measurement procedure - a procedure to define and confirm compliance of measurement techniques to the relative metrological requirements (GOST R 8.563-96).

Personnel certification (certification of personnel related to the non destructive testing of equipment and pipelines, elements and structures of nuclear facilities) - a procedure to define the qualification of personnel or to attest the conformity of personnel qualification to the requirements established by any method of non destructive testing equipment and pipelines, elements and structures of nuclear facilities, with the issuance of qualification certificate (RD EO 0583-2004).

Verification of software - evidence, that the software performance conforms to the specification of this software (GOST 19781-90) .

Reproducibility of testing results - identical testing results obtained by the same method (same technique), on identical test samples, in different laboratories or at different sites, by different operators using the same type of testing (GOST R 50779.10-2000).

Detectability of defects - probability to detect defects by defining their parameters (V.N Volchenko book [4]).

Master samples of testing - objects of development, used at the same time as first samples of non volume and low-volume testing tools, being developed according to the special conditions of supply (the term "master samples of testing" is defined in accordance with GOST R 15.201-2000).

Defect - every single unacceptable deviation from the requirements for equipment and pipelines, nuclear facilities elements and structures, defined by the applicable documents in the field of atomic energy use (the term "defect" is defined in accordance with PNAE G G-7-010-89 and GOST 15467-79)*.

Confidence probability (confidence level) - the value of (1 - α) - probability, associated with a confidence interval or a statistically covering interval (GOST R 50779.10-2000).

Reliability of non destructive testing (NDT) - NDT indicator, associated with the probability of making error-free conclusions about presence or absence of defects. (Handbook ... [47]) .

Client - an enterprise (organisation, association or other business entity), which receives services (according to the application or contract) of development (modernisation), production and (or) delivery of products (R50 -605-80-93).

Manufacturer - a company (organisation, association) that manufacture products. Manufacturer can be also a supplier of products. (P50 -605-80-93) .

Measuring system - a set of functionally integrated measures, instrumentation, transmitters, computers and other equipment, located on different points of the tested object etc., aimed at measuring of one or more physical parameters pertaining to this object, and at developing of measurement signals for different purposes (RMG 29-99).

Measurement testing - inspection exercised with the use of measurement instruments (GOST 16504-81).

Tests - experimental determination of quantitative and (or) qualitative characteristics of the tested object properties, as a result of impact on it during the operation, or during the object and impacts modelling (GOST 16504-81).

* In this document the term "defect" is defined as any deviation from the established requirements: discontinuities, alteration of geometrical dimensions and shape (deviations from the nominal values), changes of structure (grain size) and mechanical properties (hardness, resistance) etc.

Test sample - design, that fully or partially replicates the real object of testing or a part of it and reproduces its characteristics (defects); is used to verify the operational NDT tools and methods, designed to assess characteristics (defects) of real objects of testing in accordance with the requirements of the normative documents (the term "test sample" is defined in accordance with GOST 8.315-97, GOST 23829-85, RMG 29-99 and recommendations of IAEA and ENIQ).

Calibration of measuring instruments - a set of operations to determine and confirm the actual values of metrological characteristics and (or) the serviceableness of a measurement instrument, that is not subject to the state metrological testing and supervision (GOST 8.565-96).

Test category - test mode, characterised by an organisational way of their conducting and decision making after the evaluation of NDT tools and methods as a whole. Test category is characterised by its organisational attributes, such as - level (state, interagency, inspection), stages of development (preliminary, acceptance) (GOST 16504-81).

Material research organisation - an organisation, approved by the relative authority of atomic energy use to provide services to the operating organisation or other organisations for the selection of materials, welding, quality assurance of equipment and pipelines and to perform the examination of design, engineering, technical documentation and documents, that justify nuclear and radiation safety of nuclear facilities and has a license of “Federal Environmental, Industrial and Nuclear Supervision Service of Russian Federation” for this type of services. (Amendment №1 to the PNAEG 7-008-89 rules).

Testing method - rules of application of certain principles and testing tools (GOST 16504-81) .

Destructive testing method - a method of testing, which can destroy the serviceableness of the tested object (GOST 16504-81).

Testing method (guidance document, manual) - organisational guidance document, mandatory for implementation, that includes the description of objects to test, testing method, tools and conditions of testing, algorithms of operations to determine one or several interrelated characteristics of the object properties, forms of data presentation and accuracy estimation, results reliability, safety and environmental protection requirements (the term "testing method" is defined in accordance with GOST 16504-81 and Handbook [47]).

Methods of measurement (MM) - a set of tasks and rules, which implementation provides results of measurements with the known error (GOST 8.563-96).

Metrological support - determination and application of scientific and institutional basics, technical tools, rules and regulations, necessary to secure the unity and the required accuracy of measurements (Glossary [12]).

Metrological examination of MM - analysis and evaluation of the choice of measurement tools and methods, tasks and rules of measurement and their results processing in order to ensure MM compliance to the metrological requirements (GOST 8.563-96).

Morphology of defects - complex scientific knowledge about the shape, structure and mechanisms of defects formation (Technical Dictionary).

Worst-case defection situation - the term refers to the simultaneous presence of defects and complex geometry of component etc., thus making difficult to identify and/or accurately measure the size of defects. using specific NDT tools and methods (report ENIQ № 12).

Non-rejection - defection of at least one of the objects, that were considered valid after the testing (Glossary of terms [48]).

Non-destructive testing - testing, that should not cause any damage of equipment and piping, components and structures of nuclear facilities being operated. (the term "non destructive testing "is defined in accordance with the Handbook [47] and RD EO 0583-2004).

Discontinuity - violation of the homogeneity of material, that causes an abrupt variation of one or more physical characteristics - density, magnetic permeability, speed of sound, wave resistance etc. (Handbook ... [47]).

Nonstandard measurement tool - a tool of measurement, standardisation requirements for which was considered inappropriate (RMG 29-99).

Nuclear facility - nuclear installation, source of radiation, storage of nuclear materials and radioactive substances, radioactive waste storage facilities. ("Law on the use of Atomic energy").

Object of NDT - equipment and pipelines, elements and constructions of nuclear facilities that are subjects to non-destructive testing. (the term "object NDT" is defined in accordance with Handbook [47] and RD EO 0583-2004).

Prototype of testing tool - prototype of testing tool, made in accordance with the newly developed working documentation to verify by testing its compliance to defined technical requirements, in order to make decision about the possibility to launch it into the production and (or) to use it as intended (the term "prototype of testing tool" is defined in accordance with GOST 15467-79).

Sensory testing - testing, where the primary information is perceived by the sense organs (eg. visual inspection) (GOST 16504-81).

Open tests - practical tests performed by the personnel informed about the type, quantity and characteristics of test samples, as well as the morphology of defects, their location and size in the test samples to be detected and/or evaluated. (Document IAEA IAEA-EBP-WWER- 11).

Over rejection - defects in at least one of the rejected objects according to the results of testing (Glossary of terms [48]) .

Personnel related to the non-destructive testing of equipment and pipelines, elements and structures of nuclear facilities (hereinafter personnel) - specialists (NDT specialists, operators, repairers, supervisors, technicians, engineers etc.), that directly perform non destructive testing of equipment and pipelines, elements and structures of nuclear facilities, certified as prescribed to the appropriate level of qualification according to the examination methods, specified in their certificates of competency (RD EO 0583-2004).

Verification of measurement tools - a set of tasks, carried out by the state metrological service (other authorised agencies and organisations) to identify and confirm the measurement tools compliance to the technical requirements (GOST 8.565-96).

Repeatability of testing results - identical testing results obtained by the same method (same set of methods), on identical test samples, in the same laboratory or at the same site, by the same operator, using the same testing tool and in a short time interval (GOST R 50779.10-2000).

Measurement error - a deviation of the measurement result from the true (actual) value of the parameter being measured (RMG 29-99).

Supplier - an enterprise (organisation, association), which supplies NDT tools and methods, as specified (the term "supplier" is defined in accordance P50-605-80-93).

Postulated defect - defect, which presence is expected in the tested object, but its characteristics are not known and, therefore, they must be postulated using the experience gained by studying similar defects, that occur in other tested objects (Document IAEA IAEA-EBP-WWER-11).

Acceptance tests - controlling tests of tools prototypes and NDT draft methods and (or) experimental batches of NDT tools or single production NDT tools, held respectively in order to address the question of appropriateness to launch the production of these tools and (or) to use the NDT tools and methods as intended (the term "acceptance tests" is defined in accordance with GOST 16504-81).

Commissioning tests - controlling tests of NDT tools during the acceptance testing. Commissioning tests are usually carried out by the manufacturer of NDT tools. (the term "commissioning tests" is defined in accordance with GOST 16504-81).

Tests program - organisational guidance document, mandatory for implementation, that defines the object and the target of tests, types, sequence and scope of experiments to conduct, order, conditions, tests location and terms, support and reporting, and also the responsibility for ensuring and conducting the tests (GOST 16504-81).

Software tool - policies, procedures, rules, and, if provided, accompanying documentation and data, related to the operation of the information processing system (GOST 28806-90).

Developer - an enterprise (organisation, association), that develops tools and/or methods of testing (P50 -605-80-93).

Recognizability of defects - probability to identify significant differences in the parameters of different forms and types of defects (V.N. Volchenko [4]).

Real defect - defect, which was formed in a component of equipment or pipeline, in the construction of nuclear facility during its production or operation without any intentional intervention to stimulate its formation (Report ENIQ № 12 , EUR EN 18102. Glossary ENIQ: Second Edition).

Realistic defect - defect, artificially introduced into the test sample, that simulates technological or operational defect. To solve the problems of certification, the most suitable types of realistic defects are those, which response to the non destructive testing is similar or identical to the responses caused by real defects for the methods of nondestructive testing to be evaluated (Report ENIQ № 12, EUR EN 18102. Glossary ENIQ: Second Edition).

NDT result - defined evaluation of conformity of the tested object to the technical requirements, understood as a result of comparison of the final information about the test ed object to the regulatory and technical documents (Handbook ... [47]).

Testing system - a set of testing tools, performers and defined objects of testing, that interact according to the rules established by the relative regulatory documentation (GOST 16504-81) .

Certification system of equipment, products and technologies for nuclear installations, radiation sources and storage units (EPT) - the system, that defines its own rules, procedures and management for carrying out the certification of conformity (ITD -013- 2000).

Blind tests (closed) - practical tests, which are conducted by personnel, who:

- are not informed about location, number and size of defects in a test sample;
- are not informed whether there are any defects in the test sample;
- do not have access to defects on the tested surface of the test sample;
- do not have access to the marking (labeling) of the test sample.

(Document IAEA IAEA-EBP-WWER- 11).

Measurement device - technical device for measurement with normalised metrological characteristics, that reproduces and (or) stores a unit of a physical parameter, which size is considered to be invariable (within the defined error) for a certain time interval (RMG 29-99).

Non destructive testing tool - technical device, substance, material, software, used to receive and process information about the object of NDT (the term "non-destructive testing" is defined in accordance with GOST 16504-81 and Handbook [47]) .

Technical confirmation - documentary evidence, that attests the evaluation of capacities of the proposed system or the NDT tool and justifies the choice of basic testing parameters and their ranges, the amount of required practical tests, the use of real or realistic defects and other requirements (Document IAEA IAEA-EBP-WWER- 11).

Defectiveness level - the ratio of the number of defective elements to the total number of inspected elements, expressed in percentage. (V.N. Volchenko [4]).

Functional tests - tests carried out to determine values of the object destination indicators (GOST 16504-81).

Operational testing - testing performed during the operation of equipment and pipelines, components and structures of nuclear facilities (the term "operational testing" is defined in accordance with GOST 16504-81 and Handbook [47]) .

Operating organisation - an organisation, established in accordance with the legislation of the Russian Federation and qualified by the relevant governing body of the use of atomic energy for exploitation of a nuclear installation, radiation source or storage and for exercising independently or with the assistance of other organisations activities of locating, design, construction, operation and decommissioning of a nuclear installation, radiation source and storage, as well as activities for management of nuclear materials and radioactive substances (Law "On the Use of Atomic Energy").

Effectiveness of testing - a combination of factors, that determines technical applicability of testing: tested objects evaluation reliability, productivity, range of use, recognition of defects, reproducibility, costs etc. (V.N. Volchenko [4]).

1. General conditions

1.1. Standard requirements for the method of development, tests and use of tools and methods for operational NDT on nuclear facilities (hereinafter - Standard requirements) are developed on the basis of the federal law "On the use of Atomic Energy", following the development of the state and industry standards "Systems of development and launch of new products" GOST 15.201-2000, GOST 15.005-86, OST 9518-2001, that regulate general approaches to the method of development and launch of new products, taking into consideration the recommendations of the "Certification methodology of operational testing systems for nuclear power plants with WWER reactors" IAEA IAEA -EBP-WWER-11 and the "European certification methodology of non destructive testing" ENIQ, to ensure the quality of equipment supplied to the nuclear facilities in use or the facilities under construction in the Russian Federation (hereinafter - nuclear facilities).

Document specifies the development procedures, acceptance tests and application of operational NDT tools and methods.

1.2. Standard requirements apply to newly developed operational NDT tools and methods for nuclear facilities. Standard requirements are applicable to the operational non destructive testing tools and methods (hereinafter NDT), that use any of the methods of nondestructive testing, and determine the order of development, acceptance and use of operational NDT tools and methods. The list of basic NDT methods used on nuclear facilities is provided in Annex 1.

1.3. Safety classes of operational NDT tools are defined by the nuclear facility project developer, according to the general safety requirements.

1.4. Standard requirements are mandatory for operating organisations, project design organisations, clients, developers, manufacturers (suppliers), operational NDT tools and methods developed for nuclear facilities .

2. Development of operational NDT tools and techniques for nuclear facilities

2.1. Development and manufacture of operational NDT tools for nuclear facilities have to be guided by organisations with qualified personnel, technological and control services and technical tools, necessary to perform related tasks by itself or using contractors.

Development and production of operational NDT tools for nuclear facilities have to be conducted by organisations licensed “Rostechnadzor” for relative activities.

2.2. Development and manufacture of operational NDT tools, as well as development of operational NDT methods for nuclear facilities have to be conducted in accordance with the quality assurance programs developed according to the ISO 9001 - 2001 requirements. [18]

2.3. Development of operational NDT tools has to be performed in accordance with GOST 15.201-2000 [20] and, in general, has to include the following actions or stages:

- development, conformation and approval of technical specifications for the Research & Development (R&D);
- development and examination (if necessary) of technical documentation (including the draft of NDT techniques). Necessity of the examination and its order are determined by the client;

- development of prototypes (experimental batches);
- tests and acceptance of tools prototypes (experimental batches) and NDT draft methods;
- certification of developed operational NDT tools, as specified in the terms of reference (TOR) for the R&D (in the GOST R system, in the EMP system if present in the Nomenclature [3]; if the NDT tool is an instrument of measurement - according to the approval of the instrument type etc.);
- decision to apply the NDT tools on nuclear facilities and to include the documentation (of the NDT method) into the nuclear facility project design and/or standard programs (regulations) of operational testing for nuclear facilities;
- decision to launch the operational NDT tools into the production (if necessary into the serial production).

Stages of the specific R&D (a part of the R&D), as well as their acceptance have to be defined in the terms of reference for R&D (a part of R&D) and in the agreement (contract) for its implementation.

3. Order of development, conformation and approval of terms of reference (TOR). Terms of reference content.

3.1. Terms of reference (TOR) is a reference document for the development of testing tools and methods (or measurement procedure for measurement instruments) and all necessary documentation.

3.2. **Terms of reference is developed and approved by the client. It is allowed that the development of terms of reference is done by the executor in accordance with the original requirements of the client.** In this case the approval

procedure for the TOR remains the same.

3.3. Terms of Reference has to:

- be approved by the developer (manufacturer or supplier). The approval of TOR by the developer (manufacturer or supplier) can be carried out after the client approval, in case the developer (manufacturer or supplier) is determined through a competitive selection;
- be agreed with the operator;
- be agreed with the leading material research organisation (if necessary);
- be agreed by the project developer of nuclear installation, where the operational NDT tool and method have to be supplied, and/or by the project developer of nuclear facility, according to the responsibility for the related aspects of design (in terms of characteristics of the target use of developed operational NDT tools and methods: types of defects, mechanisms of their formation and development, in terms of geometrical dimensions and location of defects to be detected during the operational NDT, in terms of justifying the safe operation and structural integrity of the monitored components. See paragraphs 3; 4.2.1. - 4.2.3., 4.6 of Annex 2);
- pass the metrological examination of the metrological service, that is operating the nuclear facility, or of the metrological services of the State scientific metrological centres of “Rostechregulirovanie” (Federal Agency on Technical Regulating and Metrology) or specialised organisation, accredited by “Rostekhregulirovanie” for relative services, if the developed tool is a measuring instrument [17, 37];
- be approved by “Rostekhnadzor” (Federal Service for Ecological, Technological and Nuclear Supervision), in accordance with the regulations of “Rostekhnadzor”.

TOR has to be sent for conformation, metrological examination and approval to “Rostekhnadzor” by the client.

3.4. TOR is applied to the stages specified in the agreement (contract), including development, production and acceptance of the operational NDT tools and methods, as well as the approval of the experimental sample (prototype; pilot batch) acceptance certificate and the completion of prototype and the technical documentation with the acceptance tests results; thereafter the NDT tool is regulated by a normative document (standard, TOR). The application of TOR is terminated after the acceptance of the experimental sample (prototype) or of the last sample of the experimental batch.

3.5. TOR has to specify the procedure for delivery and tests of developed operational NDT tools and methods, taking into consideration the requirements of ISO 9001-2001 for the monitoring and tests procedures [18].

The procedure for delivery and tests of developed operational NDT tools and methods has to contain:

- types and quantity of developed and produced samples of NDT (experimental samples, prototypes);
- categories of tests (preliminary, acceptance etc.);
- tests location;
- list of documents submitted for acceptance tests (Section 5 of this document).

3.6. Terms of reference, as a minimum, should consist of the following sections:

- justification for development;
- name and field of application (use) of operational NDT tools and methods;

- aim and destination of operational NDT tools and methods;
- technical requirements for operational NDT tools and methods;
- list and composition of output documentation;
- requirements for the confirmation of the NDT tools conformity to the mandatory requirements (see p.6 of Annex 2);
- stages and phases of development;
- delivery and tests method;
- test procedures for type approval (for measuring instruments);
- sources of development;
- economic indicators (if required by the client).

It is allowed to clarify the content of sections and introduce new sections.

The detailed procedure for drafting, presentation, and formalisation of TOR for the development of operational NDT tools and methods is provided in Annex 2 of this document.

4. Order to conduct tests of operational NDT experimental samples (prototypes) and draft methods.

4.1. To evaluate and monitor quality of the results, obtained at certain stages of development, experimental samples (pilot batch) of operational NDT tools (prototypes) and draft methods of testing are exposed to control tests in the following categories:

- preliminary tests (factory), conducted in order to get preliminary assessment on compliance of operational NDT tools prototypes and draft methods to the TOR requirements, and to determine their promptness for the acceptance tests;

- acceptance tests, carried out to assess all defined TOR characteristics of operational NDT tools and draft methods, to examine and confirm experimental sample compliance to the TOR requirements in conditions very close to the real operational (application, use) conditions, to certify operational NDT tools and draft methods and to make decisions regarding their possible use on nuclear facilities, and production of NDT tools (and if necessary tools replication);
- tests to confirm types of measurement instruments and certification of measurements techniques, if in accordance with the requirements of TOR, the developed operational NDT tools are measuring instruments. These tests have to be conducted in accordance with the PR 50.2.009-94 [42] rules and the MI 2441-97 [45] recommendations, while the certification of measurement techniques in accordance with the recommendations of GOST 8.563-96 [16] OST 95 10430-2003 [37] and MI 2377-98 [44]. These tests are carried out by the State scientific metrological centres of the Federal Agency on Technical Regulating and Metrology ("Rostekhregulirovanie") or other accredited specialised organisations. Tests to confirm types of measurement tools have to be performed before the acceptance tests, or can be combined with the acceptance tests of operational NDT tools and methods.

Preliminary tests of operational NDT tools and draft methods and tests to confirm types of measurement tools are organised by the developer (manufacturer or supplier).

Acceptance tests of operational NDT tools and draft methods are organised by the client.

The organiser is responsible for conducting tests.

4.2. Location to test operational NDT tools and draft methods is defined by the developer (manufacturer or supplier) together with the client.

4.3. Prototypes of non-serial tools of operational NDT are subject to the acceptance tests in order to make a decision about their targeted use, and for repetitive non-serial tools of operational NDT - also in order to make a decision about their launch into the production.

In a batch of operational NDT tools, the acceptance tests are performed on the prototype, and other samples of operational NDT tools are used for commissioning tests.

4.4. Preliminary (factory), acceptance and commissioning tests are conducted according to the relative programs and tests procedures (hereinafter - test programs), developed by the developer (manufacturer) or supplier, using the test methods that ensure test results within defined accuracy and reliability .

Test programs are developed according to the TOR requirements, the design documentation, using (if necessary) standard programs, standard (standardised) test procedures and other regulations regarding the organisation and tests conduction.

Test program includes the following sections:

- description of the tested object;
- tests destination;
- key documents;
- tests amount;
- tests conditions and methods;

- tests logistics;
- technical requirements for the selection or production of test samples for the tests that simulate real tested objects (can be defined in a separate document, see Annex 3);
- metrological support of tests;
- responsibility for tests conducting;
- identification of discrepancies during the tests;
- test reporting.

Test program also includes lists of specific audits (tasks, evaluations), which should be carried out during the tests to confirm the TOR requirements, with reference to the relative test methods. Program and method of acceptance tests of operational NDT tools and draft methods has to contain, besides tests itself, the tests criteria for the conformity assessment of project design and operational documentation (including project technical specifications) to the TOR requirements.

Test procedure includes:

- description of the tested object;
- tests destination;
- measured parameters (in accordance with the TOR requirements);
- tests conditions and methods;
- methods of analysis and processing of tests results;
- evaluation criteria (of acceptance or rejection) of operational NDT tools and draft methods;
- description of used stands, experimental samples, test tools, as well as monitoring and measurement tools;
- reporting.

If acceptance tests are combined with tests to confirm types of measurement tools and certification of measurement techniques, the program and the test method have to be developed in accordance with the requirements of 50.2.009-94 PR [42] and recommendations of MI 2441-97 [45], GOST R 8.563-96 [16] OST 95 10430-2003 [37] and recommendations of MI 2377-98 [44].

4.5. Programs and methods of acceptance test have to:

- be signed by the developer (manufacturer or supplier);
- be agreed with the operating company;
- be agreed by the project developer of nuclear installation or by the project developer of nuclear facility, that is the object of supply;
- be agreed with the material research organisation (if necessary);
- be agreed with the Federal Agency on Technical Regulating and Metrology ("Rostekhregulirovanie") or other accredited specialised organisation (if acceptance tests are combined with the tests too confirm types of measurement tools and certification of measurement techniques);
- be approved by the client;
- be approved by "Rostekhnadzor" (Federal Service for Ecological, Technological and Nuclear Supervision), in accordance with the regulations of "Rostekhnadzor"

4.6. Program of operational NDT tools and draft methods acceptance tests may include several stages, for example: tests at the site of manufacturer (supplier) on test samples and tests directly on the tested object. The necessity for operational tests on real tested objects is defined by the client or by the operating organisation in agreement with the developer, as specified in TOR. The document with the test results of the previous stage should contain the recommendations about the possibility of submitting

operational NDT tools prototypes and draft methods to the next stage.

4.7. For the acceptance tests the client (operating company) assigns the acceptance commission, a collegial body, that determines the possibility to use operational NDT tools and draft methods on nuclear facilities and their further production (if necessary).

4.8. By the beginning of tests, all preparatory activities have to be completed. The preparatory activities for tests include:

- availability, suitability and promptness at the tests location of logistic and metrological support, that guarantee required tests conditions and regimes, as defined in the test program;
- training (if necessary) of personnel, accepted to conducts tests;
- nomination of acceptance commission;
- timely submission to the test location of the tool prototype and the NDT draft method together with a set of project design, regulatory, reference and other documentation defined in the test program.

4.9. Acceptance tests of operational NDT tools and techniques drafts have to be carried out on test samples, that simulate the testing object. **Test samples should have real or realistic operational defects or deviations from the nominal geometrical dimensions, or deviations from the nominal mechanical properties etc., for an adequate assessment of operational NDT tools and draft methods.** In quality of test samples may be used real tested objects, cut from the regular or experimental products and containing real defects in the form of discontinuities or deviations from the nominal geometrical dimensions and shapes, or mechanical properties etc., in this case, the comparison has to be made between the testing results obtained by the tested operational NDT tool and draft method and the results of the NDT method of reference (see 4.2.2. of Annex 2) for a correct assessment of the tested operational NDT tool and draft methods.

In some cases, when production of test samples (for material defects such are discontinuities) is not possible, it is allowed to perform acceptance tests on real objects with the certification of the defects, identified by the tested tool and using the tested draft methods, with the following stratified sampling and conducting after each selected stratum of visual and measurement testing, capillary control, etc.

4.10. **For acceptance tests it is prohibited to use standard samples (SS), that are designed for tuning and calibration of operational NDT tools, and test samples, that do not contain realistic or real defects.**

4.11. Technical requirements for the development and production of test samples, that will be used for acceptance tests to assess conformity operational NDT tools and draft methods to the TOR requirements.

Technical requirements for the development and production of test samples have to be drafted, agreed and approved before the development of the test program in order to ensure enough time to produce test samples. Technical requirements for the development and production of test samples are formalised in the same manner as TOR.

Recommendations for the preparation of technical requirements for the development and production of test samples are provided in Annex 3 of this document.

4.12. During the acceptance tests of operational NDT tools and draft methods, tests of two types may be conducted: **open** or **"blind"**. Required type of acceptance tests for an operational NDT tool and a draft method has to be specified in TOR and in test program.

Open tests are tests of operational NDT tools and draft methods, that are conducted by personnel, who is informed about location and characteristics of defects in test samples. The purpose of open test is to show the adequacy of the testing method to the testing tasks, specified in TOR, and that the precise execution by personnel (or team of operators) of the operations specified in testing method ensure the ability of personnel to perform tasks of identifying and determining sizes of defects in accordance with the requirements of TOR, without defining quantitative reliability of testing. During such tests the main highlights of operators work and their decisions are marked and documented.

During the open acceptance tests, the development and production of test samples is performed by the developer or the supplier together with the client and, if necessary, with the assistance of organisations specialising on that specific NDT method, to which an operational NDT tool and a draft method are related.

"Blind" test are tests, which are conducted by personnel, who is not informed about location and characteristics of defects in test samples. Blind tests are used for functional test of NDT (equipment, NDT method, personnel, certified to test specific objects of testing, using specific methodology, specific equipment or operational NDT tools), in order to fully assess operational capabilities of the operational NDT system, and, if required by TOR, quantitative parameters of testing reliability. Conclusion about the results of tests is done according to the evaluation criteria, defined in the test program and the test procedure. It is necessary to be sure, that the information about defects location and size is really unavailable to the personnel.

In case of blind acceptance tests, the development and manufacturing of test samples has to be done by the client and, if necessary, with the assistance of the organisations specialised in that NDT method, related to an operational NDT tool and a draft method.

In case of blind acceptance tests, TOR for the development and production of test samples shall be confidential. Therefore, TOR has to be developed by the client, if necessary, with the assistance of other organisations for development and production of test samples, and, in any case all the information about defects in test samples shall not be known to the developer or the supplier of operational NDT tools and draft methods, and to the personnel who performs monitoring of the acceptance tests. Acceptance tests performed publicly are not subject of these restrictions.

In case of blind acceptance tests the passport content of test sample is also confidential. During and after the manufacture of test samples, the access to monitored surfaces of test samples has to be limited to personnel, who are going to participate in the acceptance tests (NDT specialists, inspectors, operators) to exclude the possibility to identify visually a discontinuity of defected surface.

4.13. The data provided in TOR and the actual data, obtained during tests is reflected in comparative tables in the report (reports) of tests, which are attached to the act of the acceptance commission.

4.14. The test are considered finished with a positive result, if the results are formalised in an act, that confirms the testing program effectuation and contains evaluation of tests results, together with specific and precise statements, that reflect the conformity of tested operational NDT tool test sample and draft method to the TOR requirements.

5. Documentation to provide for the acceptance tests of operational NDT tools samples and draft methods

The following documents have to be submitted for the acceptance tests:

- terms of reference (TOR) - agreed, approved and authorised as required;
- preliminary (factory) results, formalised in protocols or acts;
- draft of technical conditions (if required by TOR);
- program and procedure of acceptance tests - agreed and approved as required;
- general outline drawing of NDT tools;
- testing techniques draft (instructions, rules and regulations) and/or measurement techniques draft;
- operational documents (in accordance with the requirements specified in tTOR and GOST 2.601-95 [13]);
- all expert opinions, carried out during the development process.

In addition, it can be presented a technical justification or confirmation (section 5.3 of this document), which includes calculated and theoretical justifications of possibility and effectiveness of using the developed NDT tools and methods and results of practical experience of using similar NDT tools and methods.

Documents provided for review to the acceptance commission, have to be sent in advance (at least two weeks before the commission) to members of the commission for preliminary review.

5.1. NDT draft method.

A newly developed testing method (instruction), that utilises NDT tools, as well as a testing method (instruction) for review, have to be developed according to the technical specifications of TOR. The NDT method should contain the following sections:

- destination of the testing method;
- description of applied testing techniques and modes;
- requirements for equipment, instruments and auxiliary tools;
- preparation for testing;
- conduction of testing;
- quality evaluation of the tested object and formalisation of testing results;
- qualification requirements for personnel, performing NDT;
- requirements for metrological service;
- safety requirements.

The detailed procedure for drafting, presentation, and formalisation of TOR for the development of operational NDT tools and methods is provided in Annex 4 of this document.

If the TOR requires a measurement procedure to be developed, the procedure is drafted in accordance with the requirements of GOST 8.563-96 [16], and recommendations of MI 2377-98 [44].

5.2. NDT draft method of NDT has to be agreed, approved and authorised:

5.2.1. Prior to acceptance tests:

- signed by the developer (manufacturer or supplier);
- agreed with the customer (operator);
- measurement procedure draft (for measurement instruments) has to be certified (R 8.563-96 [16] OST 95 10430-2003 [37], MI 2377-98 [44]) and approved by the State scientific metrological centre of Federal Agency on Technical Regulating and Metrology ("Rostechregulirovanie") or specialised accredited organisation (if the acceptance tests are not compatible with tests for type approval of measurement tools and certification of measurement techniques);

5.2.2. Upon successful completion of acceptance tests:

- measurement procedure draft (for measurement instruments) has to be certified and approved by the State scientific metrological center of Federal Agency on Technical Regulating and Metrology ("Rostechregulirovanie") or specialized accredited organization (if the acceptance tests are compatible with the tests for type approval of measurement tools and certification of measurement techniques);
- approved by the client (by the operator);
- approved by "Rostekhnadzor" (Federal Service for Ecological, Technological and Nuclear Supervision), in accordance with the regulations of "Rostekhnadzor".

5.3. Technical justification or confirmation .

For reasons associated with the practical aspect, the number of test samples which can be used for acceptance tests is usually limited. In this case, testing of experimental

samples often provides incomplete information to confirm the possibility of proper use of operational NDT tools and methods and the reliability of testing results.

The objectives of the feasibility study and approval are:

- to overcome these limitations by obtaining information, which enables to evaluate the possibility of NDT tool and method to function at a desired level;
- to add and generalize the results of practical tests by demonstrating that the results, obtained on specific defects in the test samples, will be valid for all other possible defects;
- to ensure the technical basis for the main parameters of operational NDT tools and methods and their ranges.

It is recommended for the technical justification to describe in detail all existing theoretical and/or practical evidences, that confirm full or partial compliance of proposed draft of the NDT method and testing tools to the requirements of TOR.

Technical justification or confirmation are prepared by the developer (manufacturer) or vendor of NDT tool and method, involving organisations, that participated in the pilot study and experimental use of developed or similar NDT tools and methods, and is provided along with the other documents of acceptance commission (see paragraph 5 of this document).

Theoretical evidences may include:

- analysis of the NDT method to verify the reproducibility and repeatability of testing results by personnel, conducting testing at nuclear facilities, to minimize errors caused by the human factor;
- calculation results of tests mathematical models (if available).

In this case, the utilised models have to take into consideration specific conditions of real operational NDT, and calculation programs used for mathematical models, have to be verified.

Mathematical models can be used to extrapolate results of testing, received on the particular test samples, to the real object of testing, in order to evaluate the possibility to use simplified test samples during testing.

Practical evidences may include:

- practical experience of applying a method and corresponding tools for NDT to real testing during the validation of destructive testing methods results;
- laboratory tests to confirm results of NDT methods, based on other physical principles and results of destructive testing;
- results of similar experience of the domestic and international research programs.

An important element of technical justification or confirmation is the information obtained as a result of practical experience. However, this information should not be subjective.

6. Acceptance of the results of operational NDT tools and methods development

6.1. Results of the development of operational NDT tools and methods are evaluated by the acceptance commission. Acceptance commissions can be performed once or can operate continuously. Acceptance commissions are created by the order (decree) of client or developer with the customer consent. The acceptance is composed by representatives of client, developer, manufacturer, operating company, nuclear installation project developer or nuclear facility project developer (depends on the liability), material research organisations, organisations specialised in development of similar tools and methods for operational NDT, “Rostekhnadzor” (Federal Service for Ecological, Technological and Nuclear Supervision). The Chairman of the Commission is a representative of the client.

If acceptance tests are combined with tests for type approval of measurement instruments and certification of measurement techniques drafts, as described in paragraphs 4.4., 4.5., 5.2.1. of this document, the commission have to include representatives of the State scientific metrological centres of "Rostechregulirovanie" (Federal Agency on Technical Regulating and Metrology) or representatives of specialised organisations accredited by "Rostekhregulirovanie".

6.2 . Acceptance commission conducts acceptance tests of operational NDT tools prototypes and draft methods in accordance with the requirements defined in section 4 of this document.

6.3. Acceptance commission works in accordance with the program and the acceptance test procedure and usually consists of the following steps:

- check if the documentation comply to the requirements of TOR, in terms of content and completeness;
- check if the operational NDT tools and method drafts are ready for testing;
- check the availability of conditions for testing (test samples, stands, auxiliary and measurement devices);
- acceptance tests, review of the results of previous tests (preliminary tests);
- evaluation of quality of the operational NDT tools, documentation (including the methods drafts), possibility to apply these tools to the nuclear facilities, possibility of tools production (if necessary);
- formalization of test results.

6.4. In case tests samples of operational NDT tools and draft methods, or necessary documentation are not ready, the commission may decide to postpone their services and notify the organisation, that appointed the commission, and also to communicate the conditions under which the commission may resume its services.

6.5. If there are any discrepancies during the tests, that can prevent their continuation, the corrective actions have to be implemented to address them. This should be done by a corresponding note in the protocol and/or the act of acceptance tests. If necessary, it has to be accompanied by additional information on a separate sheet or document, drafted in accordance with the formalisation requirements for protocol and/or act.

After the implementation of corrective actions, acceptance tests have to be repeated, as defined by the Commission, and the corresponding document has to be drafted (protocol and/or act) .

6.6. Comments and suggestions are included in the act of acceptance commission with the indication of terms and conditions of tests completion (additional tests conduction, changes to the documentation etc.).

6.7. According to the results of acceptance tests and evaluation of submitted materials, the commission produces an act, that indicates:

- samples compliance of developed (produced) operational NDT tools and draft methods to the TOR requirements, possibility to use them as purposed (delivery to the client) and to launch their production (if necessary);
- assessment of technical characteristics of submitted samples of operational NDT tools;

- assessment of developed technical documentation (including the testing draft method and project specifications and other documents required by TOR);
- recommendations for possible further use of prototypes of tools and methods for operational NDT;
- recommendations for production of a batch and its volume (when working on launching the operational NDT tools into the production);
- comments and suggestions for improvement of operational NDT tools and methods and related operational documentation;
- other possible observations and recommendations.

Act of the acceptance committee has to be approved by the client (operating organisation). The approval of the acceptance committee act indicates the completion of development services and termination of TOR (if it is not valid for further services, if the act doesn't contain contain the rejection to accept the results of services, or if the act does not contain the tests postponement, or the necessity for additional tests or pilot operation etc.). Adjustment or approval of submitted technical specifications (if required by the TOR), technical and operational documentation (including the testing method and/or the measurement procedure) have to be performed after the signing of the act of acceptance commission with a positive conclusion.

6.8. In case of serial production of operational NDT tools for nuclear facilities (if required by TOR), preparation and development of production (launching into the production) have to be conducted in accordance with the requirements of GOST R 15.201-2001 [20].

6.9. Results of the acceptance tests (act, protocols and testing methods and/or measurement procedure, formalised as required) have to be sent by the client to "Rostehnadzor" (Federal Service for Ecological, Technological and Nuclear Supervision), in accordance with the regulations of "Rostekhnadzor", to prepare the conclusion about the possibility to approve the use of an operational NDT tool and

method on the nuclear facility.

Development sources

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3. "Nomenclature of equipment, products and technologies for nuclear installations, radiation sources and storage facilities, subject to mandatory certification in the System of certification of equipment, products and technologies for nuclear installations, radiation sources and storage facilities." Moscow 2000 . Approved by by the order of Ministry for Atomic Energy of Russia, as of 21.08.200, Number №283-R.
4. Volchenko V.N. "Probabilty and reliability of evaluation of the quality of metal production." Moscow, Publishing House "Metallurgy", 1979.
5. The document of IAEA, IAEA-EBP-WWER-11. "Methodology for certification of operational testing systems for nuclear power plants with WWER reactors ." March 1998 .
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7. ENIQ Report nr.12, EUR EN 18102. «ENIQ Glossary», EUROPEAN COMISSION Directorate-General JRC, Petten-Netherlands, December 1999 .
8. ENIQ Report nr.14, EUR EN 18686 . «ENIQ Recommended practice 5: Guidelines for the design of test pieces and conduct of test piece trials», EUROPEAN COMISSION Directorate-General JRC, Petten-Netherlands, February 1999 .

9. ENIQ Report nr. 4, EUR EN 18099 . «ENIQ Recommended practice 2 : Recommended contents for a technical justification», EUROPEAN COMISSION Directorate-General JRC, Petten-Netherlands, July 1998 .
10. ENIQ Report nr. 5, EUR EN 18100. «ENIQ Recommended practice 3 : Strategy document for a technical justification», EUROPEAN COMISSION Directorate-General JRC, Petten-Netherlands, July 1998.
11. ENIQ Report nr. 25, EUR EN 21761 . «ENIQ Recommended practice 8 : Qualification Levels and Aproaches», EUROPEAN COMISSION Directorate-General JRC, Petten-Netherlands, June 2005 .
12. "Engineering. Glossary", edited by M.K. Uskova and E.F. Bogdanova, Moscow, Moscow, 1995.
13. GOST 2.601-95. "Unified system for design documentation. Operational documents."
14. GOST 4.177-85. "The system of products quality parameters. Non-destructive testing tools of material and products quality."
15. GOST 8.315-97. "The State system for ensuring the uniformity of measurements. Standard samples and properties of substances and materials. General terms".
16. GOST 8.563-96. "The State system for ensuring the uniformity of measurements. Measurement procedures."
17. GOST 8.565-96. “The State system for ensuring the uniformity of measurements. Metrological support of nuclear facility."
18. ISO 9001-2001. "Quality Management Systems. Requirements.".
19. GOST 15.005-86. "System of development and launch of new products. Designing products for single and small batch production, assembled on-site."
20. GOST R15.201-2000. "System of development and launch of new products. Products for industrial applications. Procedure for development and launch of new products."
21. GOST 15467-79 . " Quality Management. Basic concepts. Terms and definitions."
22. GOST 16504-81. "Testing and quality control. Basic terms and definitions."

23. GOST 19.101-77 . "Unified system for program documentation. Types of programs and policy documents."
24. GOST 19.102-77. "Unified system for program documentation. Stages of development."
25. GOST 19.105-78. "Unified system for program documentation. General requirements for the program documents. "
26. GOST 19.201-78. "Unified system for program documentation. Terms of Reference. Requirements for content and design."
27. GOST 19.301-79. "Unified system for program documentation. Program and methods of testing."
28. GOST 19.402-78. "Unified system for program documentation. Description of the program."
29. GOST 19.505-79. "Unified system for program documentation. Operator's Manual."
30. GOST 19781-90. "Data processing systems software. Terms and definitions."
31. GOST 20415-82. "Nondestructive testing. Acoustic methods. General terms."
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34. GOST 28806-90 . "The quality of software. Terms and definitions."
35. GOST R 50779.10-2000. "Statistical methods. Probability and statistical frameworks. Terms and definitions."
36. OST 9518-2001. "Conduction of research and development work. General terms".
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40. PNAE G-7-010-89. "The equipment and pipelines of nuclear power plants. Welded joints and surfacing. Testing rules.", with the variation №1 from 01.09.00.

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45. MI2441-97. "GSI. Tests for type approval of measuring instruments. General requirements."
46. RD EO 0488-03. "Guidelines for assessing the validity of tools and techniques for non-destructive testing ", "Rosenergoatom" 2003.
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48. "Common Questions of NDT. Terminology Guide ", compiled by V.A. Voronkov, Moscow, TSNIITMASH, 2003.
49. NORDTEST report «Guidelines for replacing NDE techniques with one another», PO Box 116 , Fin- 02151 ESPOO, Finland.
50. 2001 ASME BOILER AND PRESSURE VESSEL CODE, section XI «Rules for in-service inspection of nuclear power plant components», appendix VIII «Performance demonstration for ultrasonic examination systems».
51. IAEA-TECDOC-1400 «Improvement of in-service inspection in nuclear power plants», July 2004.

52. ENIQ Report № 25, EUR 21761 EN, «ENIQ Recommended Practice 8. Qualification Levels and Approaches», European Commission, Joint Research Centre, Petten the Netherlands, June 2005.
53. «COMPARISON OF REALISTIC ARTIFICIAL CRACKS AND INSERVICE CRACKS». Mika Kemppainen, Iikka Virkkunen (Espoo, Finland), Jorma Pitkänen (VTT Manufacturing Technology), Raimo Paussu (Fortum Nuclear Services Ltd), Hannu Hänninen (Helsinki Univ. Of Technology). 8 th ECNDT Barcelona in 2002.
54. «Description and results of NDT qualification for RPV circumferential butt welds, base metal (BM), BM-cladding interface and nozzle inner radius» Ladislav Horacek NRI REZ plc. RER/4/024-Regional Workshop on Qualification of ISI Systems and Risk ISI, INETEK, Zagreb, Croatia, October 2004.
55. Big Polytechnical Dictionary. Publisher Rousseau, 1997, 2nd edition.

Annex 1

(informative)

List of basic NDT methods used at nuclear facilities

- visual and metric;
- capillary ;
- magnetic-particle;
- ultrasonic;
- radiation;
- impermeability test;
- steeloscopic;
- televisual simple and televisual metric;
- eddy current;
- spectral analysis;
- thermic.

These requirements may be applied to the tools and methods of operational NDT, based on other methods of non-destructive testing, in the presence of an appropriate regulatory and technical documentation for those testing methods .

Annex 2
(obligatory)

Contents of the main TOR sections

1. The section "Foundation for development" indicates:

- full name of documents, that provide the basis for an operational NDT tool and method development;
- organisations, that approved mentioned documents;
- general characteristic of technical and organisational issues to address during the development of the specific tool and method of operational NDT;
- necessity and feasibility of developing of the certain tool and method of operational NDT, related to: their absence; improvement of technical parameters (sensitivity, reliability performance monitoring, etc.); replacement of obsolete tools and methods on a new ones and new; automation of monitoring process, etc.

2. The section "Denomination and field of application (use) of tools and techniques for operational NDT" indicates names of tools and techniques of operational NDT and characteristics of objects (standard object) of testing, that have to be monitored by the operational NDT tool and with the operational NDT method. In the section the following information have to be provided:

- the data about all major and welding materials (type, brand, standard) used on the monitored objects;

- brief description of the technology of welding and assembly services of the monitored objects (in the case of the development of an operational NDT tool and method for a specific object);
- geometry and dimensions of the monitored objects, their deviations from the engineering requirements of regulatory documentation requirements (for specific objects of monitoring);
- surface condition of monitored facilities, including roughness and waviness, deposits, etc.;
- information about any repairs (welding), conducted during the lifetime (exploitation) of the monitored object;
- real data about the cutting shape and the root of welded joints (if any), strengthening of welded joints and surfacing welds to be monitored, if known or postulated defects are located in these areas;
- data about the U-shaped bends, about changes in the structure of the wall layers (sheet or pipe), about the presence of deposits and/or indentations (important for the monitoring of the steam generator tubes by eddy-current testing method);
- estimated location of the operational NDT tool during testing;
- restrictions to access the monitored object;
- time limits for the testing, related to the level of radiation and other environmental factors.

3. The section "Purpose and destination of operational NDT tools and methods" defines the purpose of development, destination (experimental sample or prototype production) or operational NDT tool upgrading; development or editing of NDT method and tasks solved by the development of operational NDT tools and methods (identification, classification, location detecting, defects size determining in the monitored objects, with defined rate of testing reliability and/or with defined measurement accuracy).

4. The section "Technical requirements for the operational NDT tools" indicates requirements and regulations, that define parameters of quality and operational NDT tools performance. In general, the section shall consist of the following subsections:

- composition of the NDT tool and requirements for its design and component parts;
- indicators of destination;
- requirements for metrological support of NDT tools;
- requirements for the safety of life and health of people and environmental requirements;
- ergonomics and industrial design requirements;
- operating conditions, requirements for maintenance and repairs;
- requirements for labelling and packaging;
- requirements for transportation and storage;
- requirements for disposal of waste products;
- warranty

and other in accordance with the recommendations of GOST R15.201 -2000 [20], GOST 4.177-85 [14] and OST 9518-2001 [36].

4.1. The subsection "Composition of the NDT tool and requirements for its design and component parts" generally indicate:

- name, quantity and destination of the main components of the testing tool;
- requirements for the design of the testing tool and its parts;

- requirements for the level of automation testing procedures (data collection and testing data processing, recording and reporting of testing results);
- critical mass and dimensions, and if necessary, limits of mass, dimensions of individual components of testing tools;
- requirements for protection tools (from water, harmful fumes, corrosion, decontamination solutions etc.);
- requirements for the form and structure of the instrument parts and accessories;
- requirements for the development and production of standard samples for operational NDT tools tuning during the testing and requirements for the development and production of experimental samples for acceptance tests (Annex 3 of this document);
- requirements for composite parts of the testing tool, primary and operating materials planned to be used in the composition of the tool during its production and exploitation.

Standard measurements (transmitters, instrumentation, detectors, etc.) used to develop operational NDT tools are selected to meet the requirements for measurement accuracy and have to be supported metrologically (verification, calibration) in accordance with the established procedure and have the appropriate certificate.

Non-standardised measurement instruments, utilised to develop operational NDT tools have to pass metrological certification before the acceptance tests of NDT tools.

4.2. The section “Indicators destination" specifies:

- basic parameters and performance characteristics, that define the intended use and application of operational NDT tools and methods;
- state and industry standards, international standards and standards of organisations (enterprises), specific technical requirements, types and basic parameters, methods of measurement, nomenclature of quality indicators, that set up requirements for development of operational NDT tools.

Presenting requirements, that define the intended use of operational NDT tools and methods, special attention should be paid to the following details:

4.2.1. About defects that are present or postulated in the tested object, and which should be identified by developed and/or supplied operational NDT tool and method:

- mechanisms of defect formation (degradation of the material properties - depreciation, corrosion, erosion etc.) or the possible mechanisms of defects formation;
- types of defects, their morphology and shape;
- geometric dimensions of defects to be identified (discovered);
- location of defect in the depth of the tested object and on the scheme (inside / outside), especially for radiation and acoustic testing of welded joints. Defect location relatively to the root of welded joint, to the zone of thermal impact and amplification, or defect location relatively to the surface for eddy-current inspection of steam generator tubes;
- spatial orientation of defects (inclination with respect to the vertical axis of the tested object (welded joint) and shift from the horizontal axis of the tested object (welded joint), description of the possibility of having the worst-case defection situation;

- fractography data for operational defects such as cracks, that occurred on tested facilities or similar facilities (if present).

4.2.2. About the proper use of developed and/or supplied operational NDT tools and methods:

- requirements to identify defects considering the sensitivity (absolute, threshold or relative in accordance with GOST 4.177-85 [14]);
- requirements for the testing reliability (qualitative or quantitative [4]). Quantitative requirements to the defined testing reliability have to identify the probability of detecting defects, non-rejections and over rejections for specific types and sizes of defects on tested facilities. When selecting indicators of reliability it is recommended to use the RD EO 0488-03 [46] guideline;
- requirements for recognition of defects (characteristic differences in the parameters of different defect types and forms[4]);
- requirements for detection of the remaining metal intact (ligament, if necessary);
- requirements for resolution during the defect detection;
- requirements for reproducibility and repeatability of operational testing results;
- requirements for the error of relative or equivalent parameters (sizes) of defects and/or requirements for the error of absolute parameters (geometrical dimension) of the detected defects with the required value of confidence level;

- requirements for the error in coordinates of the detected defects;
- time required for testing;
- criteria for acceptance or refusal of the application of operational NDT tools and methods.

To define the requirements for the testing reliability, it is necessary to use relative accuracy of test methods or developing operational NDT tools and methods relatively to the initial reference method or tool for operational NDT [4, 46].

Reference method - a method that provides a direct or more objective information about the quality of tested object (about presence or absence of defects in the tested object or about geometrical dimensions of the detected defects). For an objective comparative evaluation during the acceptance tests, the best reference method (for material defects such as discontinuities), if possible, is the method of destructive testing (opening defects). In case the method of destructive testing is impossible to use, as a reference method can be used the NDT method with the same physical nature as the tested method, but having better technical characteristics as compared with the test method (sensitivity, resolution, measurement of geometric dimensions etc.) and that provides more objective results of control. Or as a reference method can be used an NDT method, based on a different physical principle, comparing to the tested, that also provides more objective results of control.

4.2.3. Evaluation of parameters of the targeted use of developed and /or supplied operational NDT tools and techniques, specified in paragraph 4.2.2 may be performed, using two approaches.

4.2.3.1. **The first approach - an approach methodology ENIQ (European Network for Inspection Qualification** - European Network Certifications operational control), as described in documents [5 - 7], **which is a combination of mandatory practical tests and technical confirmation** (see Section 5.2 of this document). **With this approach, acceptance tests has to be performed on test samples containing the worst-case defection situation.** This term refers to the simultaneous presence of defects and complex geometry of the component or other conditions that are challenging to identify and/or accurately measure the size of defects, and this situation is considered in evaluation (certification) of the specific testing based on the specific testing system in use (equipment, methods and personnel). If during the practical tests will be shown, that the testing system meets the requirements of the TOR, and uniquely identifies the worst-case defection situation, it means, that the testing system will meet the requirements of the TOR and for the most "normal" (simpler) cases. In this approach, the number of defects to be introduced into the test samples for practical tests, has to be determined after careful analysis of a variety of factors, such as:

- balance between technical confirmation and practical tests on the test samples;
- definition of testing parameters, that significantly affect its results;
- importance of controlled component, in terms of its impact on the safe operation of the entire facility under testing;
- test type: open or "blind";
- assessment (certification) of testing tools, method draft and/or personnel; identifying and /or measuring the size of defects.

To reduce the number of test samples and defects that have to be introduced into the test samples, it is recommended to use the technical confirmation (see section 5.3 of this document) [9,10].

When using the approach methodology ENIQ quantitative probability of detecting defects and accuracy of nondestructive testing is not defined and is not rated.

4.2.3.2. **The second approach - an approach PDI** (Performance Demonstration Initiative - activities to demonstrated the functionality), described in documents [46, 49, 50], **that considers the detection of defects based on quantitative probability of detecting them for a representative sample of defects in tested components and quantitative assessment of the reliability of control based on the probability of non-rejection and over rejection according to the testing results.** When conducting tests using this approach, the test samples and the number of defects in these samples have to provide a representative sample of defects in terms of statistics .

4.2.3.3. **In any case, TOR, tests program and acceptance test procedure must specify one or the other approach, that will be used for assessment (certification) of tools and/or testing methods during the acceptance tests [52].**

In accordance with the recommendations of the documents [51, 50], the approach to assess the targeted use of developed and/or supplied operational NDT tools and draft methods have to be determined by the operator (or customer), together with the project developer of nuclear installation or nuclear facility and the developer of operational NDT tools and methods and will depend on:

- **importance for safety of nuclear facilities tested equipment and pipelines, components and structures** (e.g. different safety classes);

- **testing role for the demonstration of structural integrity, taking into consideration risk of failures of the tested equipment and pipelines, components and structures** (for components with high and very high risk [51,52], an approach PDI has to be used, or similar [49], and more rigorous level of certification [52]);
- economic aspects and operational value of the tested equipment and pipelines.

4.3. The subsection "Requirements for metrological support of NDT", according to the type and destination of operational NDT tools, define requirements to ensure with the required accuracy and uniformity of measured instruments the opportunity for tests, inspection and calibration of parameters and characteristics of an operational NDT tool on all stages of development, manufacture, maintenance and repair.

4.4. The subsection “Requirements for the safety of life and health of people and environmental requirements" generally indicates:

- requirements for controlling authorities;
- permitted levels of dangerous and harmful factors, arising from exposure to ionizing radiation, heat exposure, RF fields, radioactive contamination etc;
- requirements for electrical safety;
- requirements for labeling and safety signs etc.

In the case of ionizing radiation sources use, the requirements of working with these sources have to be provided.

4.5. The subsection “Ergonomics and industrial design requirements” generally indicates the technical requirements of aesthetics, as well as ergonomic requirements (serviceability, comfort, efforts required to manage and maintain etc.).

4.6. The subsection "Operating conditions, requirements for maintenance and repairs", in accordance with the type and destination of operational NDT tools indicates:

- operating conditions, under which the tools with specific operational NDT technical parameters will be used;
- requirements for resistance to external mechanical and climatic factors (temperature , humidity, atmospheric pressure, radiation, etc.);
- permitted level of mechanical stress (vibration, shock, etc.);
- time to prepare operational NDT tools after transportation and storage;
- type of service (continuous, periodic);
- requirements for the number and qualification of personnel conducting operational NDT (NDT operators, supervisors , masters etc.), for the service and maintenance personnel;
- requirements for compatibility (constructive, electromagnetic, informational etc.) with the products that are used together with the develop operational NDT tools (if necessary);
- requirements for interference safety and elimination of harmful interference to other devices (if necessary).

4.7. The subsection "Requirements for labelling and packaging " generally indicates:

- requirements for labelling of operational NDT tools and packaging;

- packaging options, based on transportation and storage conditions (requirements for materials used in packaging and method of packaging).

4.8. The subsection "Requirements for transportation and storage" generally indicates:

- transportation conditions and types of vehicles;
- requirements necessary to protect against shocks during loading and unloading;
- storage conditions (ambient temperature, temperature change, humidity, air pressure).

4.9. The subsection "Requirements for disposal of operational NDT tools" indicates requirements for waste operational NDT tool, especially contaminated.

4.10. The subsection "Warranty" indicates obligations of the manufacturer (supplier) in terms of compliance of operational NDT tools to the requirements of TOR, and the warranty period during which the manufacturer (supplier) is responsible in case of defects discovered by the user, upon condition that the user observes rules of operation, transportation and storage.

5. The section " List and contents of documentation " specifies:

- list of produced project design, technological and program documentation for the operational NDT tool to be developed (TOR; technical proposal, conceptual, technical or project design (set of drawings) specifications; passport; operation and maintenance manual; acceptance tests program and procedure; software documentation etc.), that the developer (supplier) have to provide to the client or the operating organization;

- list of documents to be agreed and approved for the stages of development and acceptance.

In a separate document have to be developed a testing method and/or or method for defect parameters measurement. Detailed requirements for the development of testing method are defined in paragraph 5.2. of this document. Development of method for defect parameters measurement have to be done in accordance with GOST 8.563-96 [16] OST 95 10430-2003 [37] and recommendations of MI 2377-98 [44].

5.1. Development of project design and technological documentation for operational NDT tools is performed in accordance with the standards of Unified system for project design documentation, Unified system for technological documentation and general project design management of GOST R ISO 9001-2001 [18]. If the composition of operational NDT tool requires software development, the requirements for it are defined in a separate TOR in accordance with the requirements of the related documents (GOST 19.201-78, GOST 19.101-77, GOST 19.102-77, GOST 19.105-78, GOST 19.301-79, GOST 19.402-78, GOST 19.505-79 [23 - 30]) or specified in TOR for the operational tools in the subsection “Software requirements" of the section "Technical Requirements" .

5.2. For repair tools of operational NDT in the agreement (contract) and TOR for the R&D is necessary to include the development of repair documentation for the preparation of the NDT tool repair and testing after the repair.

5.3. If it is necessary to examine project design, technological, programmatic or operational documentation, a list of documents to present for the expertise have to be defined, as well as stages at which it has to be conducted and location (organization). Necessity for examination of the documentation is determined by the customer and/or developer and indicated in TOR. The documentation can be sent to the parties of concerned organizations for review and comment in accordance with OST 9518-2001 [36]. Examination results, issued in the form of conclusions are provided in the kit with other documents for acceptance tests (see section 5 of this document).

5.4. **Obligatory expertise in the organization of the project developer of nuclear installation or the project developer of nuclear facility (based on the respective zones of responsibility for the design), has to be conducted for the draft method of testing and/or measurement of operational NDT tool.** The expertise is conducted in terms of completeness reflected in the draft method of targeted use parameters testing, specified in TOR (see section 3.3 of this document) and from the point of view not to reduce the safety of operation of the tested element due to the introduction of new testing tools (especially it is important for tools of intrareactor testing of technological channels, reactor vessel from inside etc.).

6. The section "Requirements for conformity assessment of products to the mandatory requirements (certification requirements)" indicates defined by the legislation and regulations form of conformity of developed operational NDT tools to the mandatory requirements.

6.1. Operational NDT tools included in the effective "Nomenclature of equipment, products and technologies for nuclear installations, radiation sources and storage facilities, subject to mandatory certification System for certification of equipment, products and technologies for nuclear installations, radiation sources and storage" [4] (hereinafter - Nomenclature), and in addition to it, are subject to compulsory certification according to the System requirements.

6.2. Certification of operational NDT tools, that are not included in the nomenclature or supplements to it, but need to be certified according to the contract between the client and the developer /manufacturer (supplier), is carried out according to the requirements of the System.

6.3. Quality management system of manufacturing of operational NDT tools for nuclear facilities are recommended to certify in the Certification System of equipment, products and technologies for nuclear installations, radiation sources and storage facilities according to the requirements of GOST R ISO 9001-2001 [18] and in accordance with the procedure established in the system.

7. The section "Stages and phases of development establishes the necessary stages of development and, if necessary, the time framework of their implementation.

8. The section "Order of delivery and acceptance " indicate requirements for:

- test category (preliminary, acceptance etc.), experimental samples (or prototypes) of operational NDT tools samples and draft methods;
- test type (open or blind, see paragraph 4.11 of this document);
- tests location;

- manufacture or selection of test samples and test benches ;
- development of the test program and the test method, and of the draft method of testing;
- composition and operation of the acceptance commission.

Questions, related to testing of experimental samples of operational NDT tools and draft methods are defined in details in section 4 of this document.

9. The section " Development sources" provides a list of key documents based on results of prior work performed in the field of development, and that have to be used to develop operational NDT tools and draft methods.

10. The section " Economic indicators" indicate approximate cost efficiency and payback of development costs, reduced testing time compared to the operational NDT tools currently in use, improvement of testing quality through better data collection and processing, automation,of the testing process and data decryption, economic advantages compared with existing domestic and foreign analogues etc.

Annex 3
(recommended)

Short recommendations for the preparation of technical requirements for the development and manufacture of test samples for the acceptance tests

Test samples have to be representative and have to match the testing objects in terms of material, dimensions, configurations of welded joints (if the method is developed for their testing) and geometry. It shall be possible to install test samples into the test or setup stands, where the operational NDT tool and method drafts will be tested.

In order to assess the operational performance of operational NDT tools and parameters of methods drafts, the test samples have to contain real or realistic defects or deviations from the nominal geometric dimensions, in order to ensure adequate assessment of the operational NDT tools and method drafts.

Ideally, the defects have to be created using the same mechanisms of damage, that occur in the tested object. Nevertheless, in practice it is not always possible, and it is necessary to use realistic defects to simulate real.

It is allowed, if possible, to use as test samples real testing objects (components) with real defects, carved out of operated or experimental nuclear facilities (see paragraph 4.9 of this document) .

Dimensions of test samples must allow necessary indents (defectless free space) to perform full testing in accordance with the method of testing, for example, one or two passes of the primary transducer for ultrasonic detection and eddy current testing etc. Test samples have to be made as far as possible in full compliance with the ordinary manufacturing process (welding) of tested objects .

Manufacturer of test samples has to check all the welds and/or primary metal in order to identify all the technological (unintended) defects using ultrasonic, radiographic or other methods in accordance with the established testing procedures. Any unintended defects should either be remove or be repair, or be recorded in the passport of the test sample being used for the evaluation of operational NDT tools and method drafts during acceptance tests.

In the technical requirements for test samples, the requirements for the following aspects have to be specified:

- design of test samples;
- number of defects introduced into the test samples;
- types of defects introduced into the test samples;
- defects distribution by size;
- spatial distribution of defects in the material of test samples;
- manufacturing technology and materials for test samples;
- mechanisms (methods) of introducing defects (mechanical processing, electric spark or electrical discharge machining, defects growing with the application of thermal and mechanical loadings, welding, implant etc.). The main condition to choose the mechanism (mode) of the defects introduction is their plausibility in terms of simulating nature (type) of selected defect for the corresponding testing method [8,49,53,54];
- links to the technical documentation, used for processes of defects introduction and welding processes;
- quality control of manufactured test samples;

- labeling;
- certification of test samples;
- confidentiality, if the test samples will be used for the blind tests.

Each test sample have to be labeled with an indication of the account number and the origin point of coordinates to locate defects or deviations from the nominal geometrical shape. On test samples of piping or equipment (templates) welds have to be etched at the processed ends and on the etched spots have to be inflicted the axis of welds.

The size distribution and number of defects, that are introduced into the test samples, will depend on the approach to the evaluation of parameters of proper use of developed and/or supplied operational NDT tools and methods (see paragraph 4.2.3. Annex 2) and other factors, for example:

- concept of combining real defect sizes with critical defect sizes for the tested component (pipe, carcass, etc);
- total number of defects, which may be introduced into the test samples;
- use of the approach ENIQ [6,7] with the **worst-case defection situation** without quantifying the detectability and/or reliability of testing, or approach PDI [50,51,49] with quantitative estimations of detectability and/or reliability of testing, determining the amount of required defects;
- test type: open or "blind".

Detailed recommendations on the number of defects to choose, using the PDI approach, depending on the requirements for their detectability and testing reliability, specified in the TOR for the development of tools and/or methods of testing, are defined in the documents [46,49].

After the respective control of procedures for experimental samples testing, independently from the type of defect they contain (real or realistic), for each sample have to be made a passport.

Passport of the test sample has to contain:

- name and description of the test sample with the attachment of drawing or sketch;
- account number of the test sample;
- brand of the metal of core elements of the test sample;
- the description of technology of manufacture of the test sample (welding technique, a mechanical handling mechanisms (tools) introducing defects, etc.);
- cartogram of location and size of defects in welds and base metal of the test sample according to the results different methods of NDT (visual and measurement, capillary, acoustic, radioactive (with conclusions and images), or other methods of control, including all reported defects, regardless of their size);
- general cartogram (by all methods) of location and size of defects in welds and base metal of the test specimen, indicating dimensional tolerances defects (defects boundaries obtained by the testing results in-process during the certification) .

General cartogram is the source document to make a conclusione on defect detection by the operational NDT tool and draft method during the acceptance tests.

In the technical requirements for test sample must be presented a justification for the choice of technology of producing defects to demonstrate, that produced defects sufficiently suit the specific method of NDT, in terms of type of postulated or representative defects.

Annex 4
(mandatory)

Sections contents and presentation of the NDT draft method

List of the main sections of NDT techniques draft is provided in paragraph 5.1, while their presentation and content is presented below.

1. The section "Purpose of testing techniques" has to specify, which objects of testing are covered by these techniques, in order to identify the operational and experimental defects under monitoring and the regulatory input for the techniques development.

2. The section "Description of the testing methods and techniques in use" has to specify selected NDT methods and techniques, provide a brief description of their physical principles, sequence or set of their application in the developing methodology, that allows to detect defects in the required test object and determine (by organoleptic exam) or measure their characteristics.

3. The section "Requirements for the equipment, instruments and auxiliary devices" should specify:

- type (model) of the equipment in use and particularities related to its operation;
- types or designs of automated tools of inverters delivery in the tested zone (for automated and semi-automated NDT systems);
- types of converters or similar devices used to obtain information;
- standard samples (SS) or standard plant samples (SPS) for configuration; auxiliary tools for equipment setting to check the basic parameters of testing; tuning and test benches or assembly;

- types and main characteristics (GOST 4.177-85) of equipment for collecting, processing and storing information;
- description of software and software products in accordance with GOST 19.402-78, 19.505-79 GOST (for automated and semi-automated NDT systems);
- requirements for auxiliary materials, supplies, accessories and their types.

If applying the SS (standard samples) and auxiliary equipment, all necessary information has to be provided for their production. If setup samples are applied to the tested object, the selection requirements and criteria for this type of use have to be provided.

4 . The section "Testing preparation" has to specify:

- position of the tested object, in which the testing is performed;
- order of tasks for preparation of the tested object;
- requirements for temperature control of the object, surface conditions, on which the transducers will be set or any other devices for collecting information;
- techniques to ensure contact between the transducer and the tested object (for contact testing methods) and utilized contact mediums;
- procedure for placement of equipment and testing of its performance prior to the inspection;
- environmental requirements and methods of accounting of its instability, if it affects the results of testing;
- selection of the main testing parameters, procedure for equipment configuration.

5 . The section "Testing conduction" has to specify:

- the order of application of selected testing methods or techniques and their variations;
- procedures and schemes for searching and fixing defects (scanning, radioscopy, audio scanning, recording, archiving etc.);
- technological scheme of testing;
- periodicity of checking the main parameters of testing in during the testing process;
- evidences of defects presence by the equipment indicators;
- characteristics of detected defects and methods for their determination;
- measurable characteristics of detected defects, methods of measurement and accuracy with guaranteed level of confidence;
- the order of tasks to perform with the indication of the methods of tested object purification from the contact mediums and their protection from corrosion, the operations sequence to bring equipment inoperable after the testing;
- values of operational NDT reliability, achieved by using this equipment, method, and necessary personnel qualification (if required by the TOR), which are confirmed during the acceptance tests or by separate technical justification or confirmation (section 5.3. of this document).

Selection criteria for quantifying the reliability of testing has to be carried out in accordance with the guidelines RD EO 0488-03 [46]. If the method requires identification of defects with different characteristics and in different objects of control, the values of defects detection have to be provided separately for each case.

6. The section "Assessment of the tested object quality and formalization of tested results" has to specify:

- standards for assessing the object quality by the results of testing (or document defining these standards);
- limit values of the characteristics to define (measure) of the detected defects, according to the adopted system of evaluation;
- accepted symbols of detected defects;
- form of the testing protocol, where to record the results for results.

The testing method have to contain clear and unambiguous procedures for data collection and analysis. The scheme for data analysis, used for decision-making about the fact, that revealed heterogeneity or deviations are defined as defects, is an important part of the methodology of testing. The testing method has to provide a clear and logical sequence all decisions related to the combination and interpretation of the results obtained by different operational NDT methods or techniques, that allow to make a final conclusion. Therefore, the scheme of data analysis of the testing process control should be sufficiently detailed.

An example of a sequence of actions to draw conclusions that have to be made in the testing process, can be the following list:

- criteria used for separation of inhomogeneities, related to the geometry of tested components and real defects;

- techniques, which allow to combine the results of different methods to make a decision on defining or non defining a heterogeneity to be a defect;
- criteria used to determining the type of defect (plane or volumetric, unsintered element or crack);
- criteria /methods used for determining (measuring) the size of identified defects.

The form of testing protocol (conclusion) has to contain the following information:

- protocol (conclusion) number;
- main technical characteristics of the tested object;
- testing location;
- the date of testing;
- notation (index) of methodological and normative documents, which were the basis for testing and quality evaluation;
- types, serial numbers of equipment and testing tool, inverters and accessories, data on their verification or calibration;
- main testing parameters;
- results of testing and schemes of testing areas of the facility (defectograms). If the results of testing revealed defects are kept in service for the purpose to study them, these defects and their characteristics has to be also specified in defectograms;
- areas of the control object not subject to testing due to their inadequacy to the requirements specified in the section "Testing preparation" or due to other other restrictions;
- full names of operators (NDT specialists), who conducted the testing, number and expiry date of their identity, their signatures;

- signature of the responsible person for organising and conducting the testing.

7. The section "Qualifications of the personnel conducting the operational NDT" has to specify requirements for the qualification and certification of personnel conducting the operational NDT and additional requirements for certification of personnel testing specific objects, with a specific method, using specific operational NDT tool. The requirements for qualification of personnel have to be defined according to RD EO 0583-2004 [41].

8. The section "Requirements for metrological support" has to define requirements of metrological support of NDT equipment NC equipment, and utilise standard samples (according to GOST) or factory standard samples, non-standard auxiliary equipment and other measurements instruments used in the testing process for measuring the characteristics of the detected defects.

9. The section "Security Requirements" has to specify requirements, compliance to which is mandatory for the objects testing by selected operational NDT methods in accordance with the normative and technical documentation.