Approved by
Order of the Federal Environmental, Industrial and Nuclear Supervision Service
No. \_\_\_ dated \_\_\_\_\_\_\_\_\_\_\_\_ 20\_\_

SAFETY GUIDE
IN THE USE OF ATOMIC ENERGY "ESTABLISHMENT AND MONITORING METHODS OF THE LIFE CHARACTERISTICS OF OPERATING ELECTRICAL EQUIPMENT AND PIPING OF NUCLEAR POWER PLANTS"

(RB-132-17)

I. General

1. The safety guide in the use of atomic energy "Establishment and monitoring methods of the life characteristics of operating electrical equipment and piping of nuclear power plants" (RB-132-17) (hereinafter referred to as the Safety Guide) has been developed in accordance with the article 6 of the Federal law No. 170-FZ dated November 21, 1995 "On the use of atomic energy" for facilitating compliance with the requirements of the following Federal Rules and Regulations for the use of atomic energy: "Rules for design and safe operation of equipment and piping of nuclear power installations" (NP-089-15) approved by the order of the Federal Environmental, Industrial and Nuclear Supervision Service No. 521 dated December 17, 2015 (registered by the Ministry of Justice of the Russian Federation on February 9, 2106, registration No. 41010) (hereinafter No-089-15); "Requirements for life management of the equipment and piping of nuclear power plants. Principal provisions" (NP-096-15) approved by the Order of the Federal Environmental, Industrial and Nuclear Supervision Service No. 410 dated October 15, 2015 (registered by the Ministry of Justice of the Russian Federation on November 11, 2015, registration No. 39666) (hereinafter referred to as NP-096-15).

2. This Safety Guide contains the recommendations of the Federal Environmental, Industrial and Nuclear Supervision Service on the establishment and monitoring methods of the life characteristics of pressurized equipment and piping of nuclear power plants during their design, engineering and operation.

3. This Safety Guide shall be applicable to the pressurized equipment and piping of nuclear power plants with pressurized water reactors, high-power pressure tube reactors, fast breeder reactors, graphite-moderated boiling-water reactor for combined heat and power, included in the life management program in compliance with the requirements of NP-096-15.

4. This Safety Guide is not applicable to the reactor pressure vessel, pumps, valves of nuclear power plants.

5. This Safety Guide is recommended for use by the legal entities and individuals carrying out design, engineering, manufacture, construction (including installation, adjustment, commissioning), operation (including during prolongation of life), reconstruction (upgrade), repair and decommissioning of the NPP.

6. This Safety Guide has been developed taking into account the domestic and foreign experience in the life management of equipment and piping of the nuclear power plants.

7. The list of the abbreviations used in these Safety Guidelines is given in Appendix No. 1, and the terms and definitions - in Appendix No. 2.

8. The approximate list of NPP equipment and piping included in the life management program and falling under this Safety Guide is given in Appendix No. 3. The operator may supplement the specified list by agreement with the developers of RP and NPP designs.

II. Recommendations for establishing life characteristics

9. The life characteristics of NPP pressurized equipment and piping are recommended to establish and justify either by the engineering (design) company at the design stage, or by the operator if for any reason these characteristics at the engineering (design) stage were not stipulated.

10. The approximate list of parameters based thereof the life characteristics of NPP pressurized equipment and piping may be determined is given in Appendix No. 4 to this Safety Guide. It is recommended to determine the life characteristics required for life managements of equipment and piping based on the parameters of the specified list or if the parameters given in it are not sufficient for determining the life characteristics, assign other parameters in addition.

11. The life characteristics of equipment and piping are determined as the maximum permissible values of the parameters given in Appendix No. 4, the attainment thereof corresponds to the exhaustion of life according to the life assessment criteria (refer section IV of this Safety Guide).

12. The list of life characteristics of equipment and piping stipulated by the engineering (design) organization is recommended to justify, besides the following may serve as justification:

references to the operation and life management experience of similar equipment at the nuclear power plants;

results of tests or trial operation of the prototypes;

computational and analytical methods;

anticipated deterioration mechanisms of equipment and piping <1>.

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<1> For new developments.

13. In cases when the life characteristics of equipment and piping are stipulated by the operator, the list of life characteristics is recommended to agree with the organization that performed design engineering (designing) of the specified equipment (excluding the cases when the design organizations ceased to exist or are foreign legal entities).

III. Recommendations for the establishment of life assessment criteria

14. it is recommended to stipulate the life assessment criteria of equipment and piping for each life characteristics of equipment and piping established for this purpose based on the following:

the requirements of the Federal Rules and Regulations in the field of atomic energy use;

requirements of national standards and other documents included in the consolidated list of documents on standardization in the field of atomic energy use, applied on a mandatory basis;

requirements of engineering (design) documentation;

other regulatory documents in the use of atomic energy.

15. A suggested list of criteria for the evaluation of life of pressurized NPP equipment and piping is given in Appendix No. 5 hereto. It is recommended to determine the life assessment criteria necessary for managing the life of equipment and piping using the specified list. If it is necessary to use other criteria for life assessment that are not specified in Appendix No. 5 hereto or additional sources for the determination of numerical values of life criteria, it is suggested that the engineering (design) organization provide justification for the need to use alternative criteria.

IV. Recommendations for monitoring methods of the life characteristics of equipment and piping

16. Monitoring of life characteristics of NPP equipment and piping is recommended to perform for the entire equipment included in the program of life management and for all piping, the life thereof is to be managed according to NP-096-15, for the purpose of periodic or continuous (using automated systems to monitor residual life) assessment of technical condition and identification of the dominant (determining) mechanisms of aging, degradation and damages of this equipment and piping.

17. The monitoring of the actual operation conditions of this equipment and these piping is the required condition for performing the life characteristics monitoring procedure of NPP equipment and piping, for which purpose it is recommended to monitor the following parameters (change of parameters):

wall temperature;

temperature of coolant or other fluid;

pressure and rate of increase or drop of pressure of coolant or fluid;s

vibration characteristics (amplitude and vibration frequency) <2>;

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<2> Selectively monitored taking into account the operation experience of reference units of equipment and piping. Places of monitoring are justified in the design.

coolant or fluid flow rate;

number of loading cycles;

displacement of monitored points of NPP equipment and piping (including geodetic monitoring);

characteristics of external and internal impacts;

parameters of chemcal cleanup and/or decontamination.

18. In addition to the parameters given in the item 18 it is recommended to perform recording and accounting of the operation time of equipment and piping in one or other mode, and accounting of the actual number of implementations of one or other mode of operation, including hydraulic (pneumatic) tests of equipment and piping for strength and density.

19. The parameters given in the item 18 hereto is recommended to monitor either by direct methods (regular or periodic measurement in the operation process), or by indirect methods (through recalculation, extrapolation or interpolation) with assessment of the measurement or calculation accuracy. If there is no regular monitoring of the periodicity of measurements it is recommended to justify.

20. If it is impossible to directly or indirectly monitor the parameters specified in paragraph 18 hereof, the operator shall establish the procedure for upgrading the NPP equipment and piping with systems and/or methods to monitor necessary parameters from the above list.

21. The recommended methods of monitoring the life characteristics of equipment and piping using the parameters given in the paragraph 18 are presented in Appendix No.6.

V. Recommendations for the collection, systematization and storage of data on electrical equipment and piping

22. For NPPs under construction and design, it is suggested that the operator organizes and adjusts the system of collection, processing, systematization, analysis and storage of information on damages, their accumulation and development, aging mechanisms, failures and malfunctioning (considering startup and commissioning), as well as on operation modes, including transient modes, hydraulic and (pneumatic) tests, and emergency situations before commissioning a NPP power unit.

23. The specified information is recommended to store for the entire life of equipment and piping as a computer database allowing immediately get all the required parameters for assessment of the residual life of equipment and piping in case of loss or damage of data.

24. The following data is entered in the specified DB for each equipment type, the life thereof is subject to management.

all nominal data for the equipment or piping in compliance with the requirements of NP-089-15;

data of manufacturers of NPP equipment and piping and data of installation organizations on deviations or no deviations from the engineering (design) documentation for the NPP equipment and piping and their manufacturing technologies, as well as data on repairs, heat treatments, additional tests;

information about the presence or absence of deviations from the engineering (design) documentation for NPP equipment and piping during their storage, shipment and handling operations;

parameters of existing deviations (if any) during manufacturing, storage, transportation and installation;

data on the monitoring of actual operation conditions of equipment and piping listed in paragraph 18 hereof;

data on damages, their accumulation and development, aging mechanisms, failures and malfunctioning;

data on pre-operational and in-service inspection;

data on corrosion activity of coolant and other fluids.

25. It is recommended to develop the mathematical tool and software of DB so that it allowed at any life cycle stage of NPP power unit to provide the possibility of

comparing source and actual values of the life characteristics of equipment and piping;

estimate of the values of life characteristics of equipment and piping before the end of their design life;

information analysis about the operation conditions of NPP equipment and piping and their impact on the life;

pretreatment and verification of available data;

data conversion.

26. DB is recommended to store using current data storage devices with mandatory duplication of information as backup copies allowing restoration of the full scope of information if required. It is recommended to use information storage media not having link with public access networks during storage of DB copies.

27. It is recommended for the operator to make a scheduled plan for development and commissioning of a computer database for the NPP in the operation stage.

Appendix No. 1 to the
safety guide in the use of atomic energy "Establishment and monitoring methods of the life characteristics of equipment and piping of nuclear power plants", approved by the Federal Environmental, Industrial and Nuclear Supervision Service order
No. \_\_\_\_\_\_\_ dated \_\_\_\_ \_\_\_\_\_\_\_\_\_\_ 20\_\_

ABBREVIATIONS

The following abbreviations are used on this Safety Guide:

|  |  |  |
| --- | --- | --- |
| EFWP | - | Emergency Feedwater Pump |
| NPP | - | Nuclear Power Plant |
| NPF | - | Nuclear Power generating Facility |
| DB | - | Database |
| FNR | - | Sodium Cooled Fast Neutron Reactor |
| BRU-K | - | Turbine Bypass Valve |
| BRU-SN | - | Steam Dump Valve to Auxiliaries System |
| VVER | - | Water cooled, water moderated power reactor |
| MSV | - | Main Steam Valve |
| - | - | Reactor Coolant Piping |
| PORV | - | Pilot-Operated Relief Valve |
| RFCC | - | Repeated Forced Circulation (Coolant) Circuit |
| - | - | Reflector Cooling Circuits |
| LWCL | - | Lower Water Communication Lines |
| CCCP | - | CPS Channels Cooling Pump |
| SWP | - | Steam-Water Piping |
| SG | - | Steam Generator |
| EFP | - | Electrical Feed Pump |
| RBMK | - | High Power Channel Type Reactor |
| RP | - | Reactor Plant |
| RLAMS | - | Residual lifetime automated monitoring system |
| ECCS | - | Emergency Core Cooling System |
| EHRS | - | Emergency Heat Removal System  |
| CPS | - | Control and protection system |
| EGP-6 | - | Heterogeneous Loop Type Power Reactor with 6 Coolant Circulation Loops |

Appendix No. 2 to the
safety guide in the use of atomic energy "Establishment and monitoring methods of the life characteristics of equipment and piping of nuclear power plants", approved by the Federal Environmental, Industrial and Nuclear Supervision Service order No. \_\_\_\_\_\_\_
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TERMS AND DEFINITIONS

The following terms and definitions are used in this Safety Guide:

1. The dominant mechanism of ageing, degradation, and damage of equipment and piping is one of several mechanisms of ageing, degradation, and damages of equipment and piping that leads to the fastest life depletion.

2. Same-type equipment and piping viz. equipment or piping presented in the RP or NPP design as a minimum in several units (for example, SG).

Appendix No. 3 to the
safety guide in the use of atomic energy "Establishment and monitoring methods of the life characteristics of equipment and piping of nuclear power plants", approved by the Federal Environmental, Industrial and Nuclear Supervision Service order
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SUGGESTED LIST OF THE
SAME TYPE EQUIPMENT AND PIPING OF NPP INCLUDED IN THE LIFE MANAGEMENT PROGRAM

1. Equipment and piping of NPP with VVER reactors included in the life management program:

MCP;

Pressurizer;

interconnecting piping (surge line);

spray piping of the pressurizer system;

bleed line of the pressurizer system;

SG;

Bubbler;

ECCS accumulators;

ECCS piping;

Emergency and scheduled cooldown heat exchanger;

Piping of emergency and scheduled cooldown system;

Piping adjoining the MCP elements (up to the first isolation valve);

Live steam piping from SG to MSV, including the steam piping up to BRU-K and BRU-SN;

Feedwater piping from the supply unit to the SG.

2. Equipment and piping of NPP with RBMK reactors included in the life management program:

Steam drum;

Repeated forced circulation circuit piping DN800;

Process channels;

CPS, reflector cooling circuit channels;

Pressure headed of repeated forced circulation circuit;

Discharge line of repeated forced circulation circuit;

Suction manifold of repeated forced circulation circuit;

Downflow pipe;

Water-levelling line;

Distribution group header;

External water and sewerage lines and steam-water communication lines and other elements of repeated forced circulation circuit;

Emergency core cooling system and piping;

Purge and cooldown system equipment and piping;

Deaerator;

Main condensate pipelines

Feedwater system equipment and piping;

Live steam piping within the reactor compartment (up to MSV-1);

Equipment and piping of CPS cooling circuit;

Regenerator and after cooler;

Piping adjoining the repeated forced circulation circuit elements (up to the first isolation valve).

3. Equipment and piping of NPP with fast neutron reactors included in the life management program:

Primary circuit pressurizer vessel;

Primary circuit rundown vessel;

Primary circuit sodium treatment system equipment (cold traps, recuperative heat exchangers, oxides indicator cold stores);

Primary circuit sodium treatment system piping;

Overflow piping (with housing enclosure) and gas compensation piping;

SFA drum (with housing enclosure);

Fresh fuel assemblies drum;

Overflow tank of SFA drum;

Non-isolated piping of SFA drum cooling system;

Air-cooled heat exchanger of SFA drum cooling system;

Sodium treatment system equipment of SFA drum (cold traps, recuperative heat exchangers, oxides indicator cold stores);

Hydraulic locks of reactor vessel, housing enclosure of reactor, SFA drum, housing enclosures of SFA drums;

Secondary circuit sodium pipelines;

Secondary circuit sodium treatment system equipment (cold traps, recuperative heat exchangers, oxides indicator cold stores);

Secondary circuit sodium treatment system piping;

Air-cooled heat exchanger of emegency shutdown cooling system;

Sodium line of emegency shutdown cooling system;

Piping part of eddy current flow meters of secondary circuit and emergency shutdown cooling system main sodium lines;

Equipment of tightness control system of reactor vessel (gas blowers, heat exchanger, accumulator filter);

Tightness control system piping of reactor vessel;

Steam generator.

4. Equipment and piping of NPP with EGP-6 reactors included in the life management program:

Steam drum;

Reactor coolant system;

Feedwater pipeline;

Plate-type filter;

Live steam line;

Turbine set;

Main condensate pipeline;

Condensate line of boilers;

Mixed-bed filter;

Main water heater;

Peak boiler;

Condensate cooler of boilers;

Deaerator;

Suction piping of FWP, NOS, EFWP

Low Pressure Heater;

Condensate cooler of low pressure heater;

Deep shutdown cooling heat exchanger.

Appendix No. 4 to the
safety guide in the use of atomic energy "Establishment and monitoring methods of the life characteristics of equipment and piping of nuclear power plants", approved by the Federal Environmental, Industrial and Nuclear Supervision Service order
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SUGGESTED LIST OF
PARAMETERS BASED THEREOF THE LIFE CHARACTERISTICS OF PRESSURIZED EQUIPMENT AND PIPING OF NPP MAY BE DETERMINED

1. Total wall thickness of equipment (or piping).

2. In-situ wal thickness of equipment (or pipeline).

3. Accumulated value of equipment (or piping) metal damage during cyclic-repeated loads.

4. Offset of ductile to brittle transition temperature of metal of welded joints and basic metal of equipment (piping) following temperature ageing and cyclic metal fatigue <1>.

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<1> Only for the equipment and piping, calculation for brittle fracture resistance thereof is mandatory.

5. Accumulated value of plastic deformations of equipment (or piping) metal.

6. Accumulated value of deformations of equipment (or piping) metal creep.

7. Change of equipment (or piping) dimensions following elastic and inelastic deformations.

8. Mechanical characteristics of structural materials of non-replaceable and replaceable equipment (piping) elements.

9. Quality change of metal structure leading to appearance of new mechanisms of its degradation and accelerated end of equipment (or piping) life.

10. Irreversible changes of equipment (or piping) process parameters following depositions, wear or chafing, change of geometric dimensions or form.

11. Vibration characteristics of equipment (or piping)

Appendix No. 5 to the
safety guide in the use of atomic energy "Establishment and monitoring methods of the life characteristics of equipment and piping of nuclear power plants", approved by the Federal Environmental, Industrial and Nuclear Supervision Service order
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SUGGESTED LIST OF
NPP EQUIPMENT AND PIPING LIFE ASSESSMENT CRITERIA

|  |  |  |  |
| --- | --- | --- | --- |
| Item | Life characteristic | Life assessment criterion (criteria) | Note |
| 1. | Operation time | Limit value set in the engineering documentation | It is recommended to enter in the data sheet and maintain record with entering of information in the data sheet. |
| 2. | Total wall thickness | Minimum value for which the requirements of calculation for section of the basic dimensions regulated by the Federal Rules and Regulations for atomic energy use stipulating the norms of strength calculation of nuclear power generating facility equipment and piping | It is recommended to enter in the datasheet and maintain control with entering of information in the datasheet (following control in accordance with the Life management Program) |
| 3. | In-situ wall thickness | Limit value for which the strength conditions during verification analysis for mechanical strength,given in the Federal Rules and Regulations for atomic energy use establishing the norms of strength calculation of nuclear power generating facility equipment and piping  | It is recommended to enter in the datasheet and maintain control with entering of information in the datasheet (following control in accordance with the Life management Program) |
| 4. | Accumulation of knowledge of metal fatigue during cyclic-repeated loads | The limit value given in the Federal Rules and Regulations in the field of atomic energy use establishing the norms of strength calculation of nuclear power generating facility equipment and piping |  |
| 5. | Offset of ductile to brittle transition temperature of metal of welded joints and basic metal following temperature ageing and cyclic metal fatigue | Limit value for which the strength conditions during brittle fracture resistance calculation given in the Federal Rules and Regulations for atomic energy use establishing the norms of strength calculation of nuclear power generating facility equipment and piping  |  |
| 6. | Accumulated value of plastic strains | Limit value for structural material set in the national or industry standards, included in the consolidated list of mandatory standardization documents in the field of atomic energy use |  |
| 7. | Accumulation of creep deformations | Limit values for rupture strength, ductility and creep characteristics of structural material established in the national or industry standards included in the consolidated list of mandatory standardization documents in the field of atomic energy use  |  |
| 8. | Changes of the sizes or form following elastic and inelastic deformations | Stipulated in the engineering (design) documentation |  |
| 9. | Mechanical characteristics of structural materials of non-replaceable and replaceable equipment (piping) elements | Limit values for engineering materials stipulated in the national or industry standards included in the consolidated list of mandatory standardization documents in the field of atomic energy use |  |
| 10. | Quality changes of metal structure leading to appearance of new mechanisms of its degradation and accelerated end of life | Stipulated in the engineering solution on clearance for operation of equipment (piping) containing the above mentioned defects on approval with the specialized material organization | It is recommended to enter in the datasheet and maintain control with entering of information in the datasheet (following control in accordance with the Life management Program) |
| 11. | Irreversible changes of equipment (or piping) process parameters following depositions, wear or chafing, change of geometric dimensions or form | Stipulated by the operator following monitoring of equipment (or piping) technical condition |  |
| 12. | Vibration characteristics of equipment (or piping) | Inadmissible frequencies or amplitudes of vibrations leading to breach of the strength conditions stipulated in the Federal Rules and Regulations in the field of atomic energy use establishing the norms of strength calculation of nuclear power generation facility equipment and piping  |  |

Appendix No. 6 to the
safety guide in the use of atomic energy "Establishment and monitoring methods of the life characteristics of equipment and piping of nuclear power plants", approved by the Federal Environmental, Industrial and Nuclear Supervision Service order
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RECOMMENDED
MONITORING METHODS OF THE LIFE CHARACTERISTICS OF EQUIPMENT AND PIPING

|  |  |  |
| --- | --- | --- |
| Item | Life characteristic | Recommended monitoring methods |
| 1. | Total wall thickness | Ultrasonic wall thickness test;Visual and dimensional inspection |
| 2. | In-situ wall thickness | Ultrasonic wall thickness test;Visual and dimensional inspection |
| 3. | Accumulation of knowledge of metal fatigue during cyclic-repeated loads | Calculation using design-basis data (at the design stage) or data on actual loading of equipment or piping (at the operation stage) or automatic method (when using AMRLS) |
| 4. | Offset of ductile to brittle transition temperature of metal of welded joints and basic metal following temperature ageing and cyclic metal fatigue | Computational or experimental methods (following the tests of specimen, metal samples) |
| 5. | Accumulated value of plastic strains | Computational or experimental methods (following the measurements) |
| 6. | Accumulation of creep deformations | Computational or experimental methods (following the measurements) |
| 7. | Changes of the sizes or form following elastic and inelastic deformations | Computational or experimental methods (following the measurements including geodetic) |
| 8. | Mechanical characteristics of structural materials of non-replaceable and replaceable equipment (piping) elements | Experimental methods (following direct or indirect measurements and/or using research in the specimen) |
| 9. | Quality change of metal structure leading to appearance of new mechanisms of its degradation and accelerated end of life | Experimental methods (following direct or indirect measurements and/or using research in the metal specimen) |
| 10. | Irreversible changes of equipment (or piping) process parameters following depositions, wear or chafing, change of geometric dimensions or form | Experimental methods (following direct or indirect measurements) |
| 11. | Vibration characteristics of equipment (or piping) | Computational or experimental methods (following the measurements) |

Note. It is recommended to apply the methods, which are included in the norms and rules in atomic energy use for control and monitoring the life characteristics, national standards (preliminary national standards), safety guides, metal control procedures, vibration characteristics control procedure.