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技術現況分析報告書

원자력 계측제어계통에 적용되는 한국-러시아의 기술기준 비교

Comparison of the Standards applied to Instrumentation and Control Systems for Nuclear Power Stations in Korea and Russia

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제 출 문

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이 보고서를 “원자력 계측제어계통에 적용되는 한국-러시아 기술기준”에 관한 기술 현황분석보고서로 제출합니다.

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요 약

본보고서는 러시아에서 원자력 안전관련 계측제어기기에 적용되는 기술기준을 한국에서 적용되는 기술기준에 대비하여 비교 분석한 것이다. 러시아도 다른 나라와 마찬가지로 원자력의 에너지사용에 관하여 전문적인 정부의 위임을 받은 규제기관을 두어 원자력 시설 및 장비의 사용허가, 취소, 감독 등을 수행한다. 러시아에서 원자력 계측제어계통에 적용되는 기술기준을 한국에서 적용되는 하드웨어 및 소프트웨어 기준과 비교한 결과 기본 원칙 및 개념은 같으나 기술기준의 문서체계, 설계요건, 시험항목, 문서의 깊이, 등이 조금씩 다른 경우가 발견되었다. 주요 차이점은 내진검증과 전자기파 기기검증에 있다. 내진검증의 경우 한국에서 적용되는 기술기준은 매우 구체적이고 시험방법이 분명하나 러시아의 기술기준은 다소 개념적이고 분명한 시험방법을 적시하지 않고 있어서 한국의 기술기준에 따라 시험한 결과가 러시아의 기준에 적합함을 시험 후에 문서적으로 증명하여야 할 것으로 분석되었다. 또한 전자기파 기기검증의 경우에는 한국의 기술기준에서 요구하는 시험항목보다 훨씬 많은 항목을 러시아의 기술기준에서 요구하므로 러시아의 기준에 맞추기 위해서는 추가적인 전자기파 시험항목이 필요하다. 그러나 이러한 추가적인 시험항목은 국제전기협회(IEC: International Electrotechnical Committee)의 시험방법을 이용하므로 이들 추가시험항목을 국내에서 수행하는 데는 문제가 없다.

Abstract

This report describes a comparison result of technical standards applied to instrumentation and control systems for nuclear power plants between in Korea and in Russia. Russia also has a state-run organization authorized to conduct approval, cancellation, and audit in use of nuclear facility or equipment. The Russian standards for nuclear instrumentation and control equipment are analogous with the Korean ones in the aspect of basic concepts and principles. However, there are some differences in document structure, design requirements, qualification test items, depth of contents between two standard systems. The biggest deviation exists in the standard documents for seismic qualification and electromagnetic interference qualification. Korean seismic qualification standard utilizing US approach, defines testing and qualification methods specifically and clearly. Russian standards however provide only conceptual definitions and requirements in the seismic related aspects. Therefore, it is conceived that any equipment or system qualified seismically in accordance with Korean standards should additionally provide technical evidence that it is satisfactory with Russian standards as well. In electromagnetic interference qualification, because Russian standard requires more testing items than the current Korean standard, the additional qualification tests are necessary to meet the Russian requirements. However, these additional test items are based on IEC(International Electrotechnical Commission), therefore it is not a problem to perform those tests in a Korean testing facility.

목 차

1. 서론

원자력발전소에 디지털 계측제어기기를 사용하기 위해서는 엄격한 기술기준에 의해서 설계와 제작이 이루어져야 한다. 각국은 이러한 기술기준을 선택하거나 제정하여 원자력설비의 안전기기에 대한 규제 혹은 허가 지침으로 사용한다. 한국원자력연구소는 디지털원자로 보호계통을 개발하면서 개발되는 제어기기의 러시아 원전 사용의 가능성을 탐색하기 위한 일환으로 한국의 주요 원자력 계측제어계통 관련 기술기준과 상응되는 러시아 규제기준을 비교하였다. 이 비교분석은 KAERI와 InterDCM사의 공동연구의 일환으로 수행이 되었으며 다음과 같은 IEEE 기술기준을 해당되는 러시아 규제문서의 내용을 비교하는 방식으로 비교하였다.

1. IEEE Std 603-1998, “ IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.”
2. IEEE Std. 7-4.3.2-1993, “ Standard Criteria for Digital Computers in Safety System of Nuclear Power Generating Stations” .
3. Regulatory Guide 1.180-2000, “ Guideline for Electromagnetic and Radio-Frequency Interference in Safety Related I & C System” .
4. IEEE Std 344-1987, “ Recommended Practices for Seismic Qualification of Class E Equipment of Nuclear Power Generating Stations” .
5. IEEE Std 323-1983, “ Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations” .
6. IEEE Std. 1012-1986. “ IEEE Standard for Software Verification and Validation Plans

기술기준에 대한 비교분석과 더불어 러시아의 원자력 설비설치이용에 관한 인허가 절차와 과정을 조사하였다.

2. 러시아 원자력 시설 설치 및 사용 인허가 절차

러시아의 실제적으로 원자력 안전규제를 담당하는 기관은 연방정부기관으로서 GOSATOMNADZOR이다. 이곳의 업무는 원자력 에너지 사용에 관한

- 안전기준, 규범(norm), 규칙 기타 규제요건 설정
- 사용허가 절차 수행
- 사찰(inspection) 프로그램 개발 및 시행
- 위반사항에 대한 제재
- 안전관련 연구
- 국가 및 공중에 보고

등이다. 원자력 사업자가 목적물의 사용을 위해서는 사용허가 신청을 내야 하는데 이를 GOSATOMNADZOR는 다음과 같은 일을 수행한다.

- 인허가신청서 접수검토(consideration of the application) 및 일차 문서 점토
- 목적물의 안전성 검토
- 인허가 승인/부결 결정
- 조건부 인허가 발행
- 사찰을 통한 인허가 지킴을 확인
- 인허가 유효기간변경, 해지, 혹은 유지

원자력설비나 기기를 외국으로부터 수입할 시에도 수입하는 기관은 GOSATOMNADROR에

- 수입기기의 유용가능성
- 기기의 기술 명세 요건
- 수입기기 사용의 영향 추정
- 기기 제작자의 (구비)조건에 대한 점검 결과

등을 포함하는 문서들을 제출하여야 한다.

3. 기술기준의 비교 분석

3.1. IEEE Std 603 에 대한 검토결과

IEEE Std 603-1988, “ IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations” 의 내용과 이에 해당될 것으로 간주되는 러시아의 기술기준을 비교하였다. 비교결과 IEEE std 603 기술기준이 보다 자세한 기술적 요건사양을 구체화하고 있다. 그러나 IEEE Std는 신뢰도의 목표가 설정되어 있는 경우에만 신뢰도 계산을 하도록 요구하는 데 반하여 러시아의 기술기준은 보호계통의 경우 강제적으로 10E-5 이하가 되도록 강제하고 있다. 이와 관련하여 분석된 러시아의 기술문서는 다음과 같다.

- OPB-88/97 (PNAE G-01-011-97), General statements of providing nuclear power plants safety, Moscow 1997.
- PBYa RU AS-89 (PNAE G-1-024-90), Nuclear safety rules for reactors of nuclear power plants, Moscow 1990.
- NP-026-01 Requirements to control systems important to safety in nuclear power plants, Moscow 2001.

추가적으로 기술적인 정의와 상위설계개념을 비교하기 위해서 아래의 두 문서를 참조하였다.

- GOST 26843-86, Nuclear power reactors, General requirements for control and protection system, Moscow 1986 (new edition in 1989)
- GOST R ISO 9000-2001, Quality management systems, Fundamentals and vocabulary.

3.2. IEEE Std 7-4.3.2-1993 에 대한 검토결과

IEEE Std 7-4.3.2-1993, “ IEEE Standard for Digital Computers in Safety Systems of Nuclear Power Generating Stations,” 의 내용과 이에 해당될 것으로 간주되는 러시아의 기술기준을 비교하였다. IEEE Std 7-4.3.2는 IEEE Std 603의 보충적인 기술기준이므로 해당되는 러시아의 문서는 IEEE Std 603의 경우와 같고 추가적으로 GOST29075-91, Nuclear instrumentation systems for nuclear power stations, General requirements (OKP 43 6240)을 검토하였다. 이것은 디지털컴퓨터의 하드웨어 및 소프트웨어에 대한 요건을 포함하고 있기 때문이다. 그러나 이문서는 디지털기기뿐만 아니라 Nuclear I&C에 대한 것을 포함함으로 적용범위에 있어서 차이가 있다.

러시아의 기술기준에서 요구되는 추가적인 규제요건에는 다음과 같다.

- 각 계통에 따른 신뢰도를 계산하기를 요구하고 이에 대한 구체적인

파라미터를 제시

- 계측제어계통의 평균(고장
- 수명은 30년이고 교체가 가능한 경우는 10년을 허용
- 원자력안전계통에는 컴퓨터운영체제(Operating System Software)의 사용을 엄격히 제한
- 보호계통에 사용되는 설정치(Set-point)에는 고정된 하드웨어나 firmware로 구현할 것을 요구

3.3. RG1.180(전자기파 장애 평가 지침)에 대한 검토 결과

전자기파의 규제기준인 Regulatory Guides 1.180, “ Guidelines for Evaluating Electromagnetic and Radio-Frequency Interface in Safety-Related Instrumentation and Control Systems,” NRC, January, 2000 과 러시아의 저자기파 관련 기술기준과 비교하였다. 해당되는 규제문서는 다음과 같다.

- GOST R 50746-2000, “ Electromagnetic compatibility of technical equipment, Technical Equipment for Nuclear Power Plants, Requirements and Test methods” .
- GOST R 51317.4.번호, “ Electromagnetic compatibility of technical equipment, ‘ 번호에 해당하는 시험항목’ ,” harmonized IEC 61000, IEC 61508, EN, ETS, CISPIR.
- IEC 61000-1-2 (referred in GOST R 50746-2000), Electromagnetic compatibility, Part 1: General, Section 2: Methodology for the achievement of functional safety of electrical and electronic equipment.
- IEC 61508 (Part1-Part7) (referred in GOST R 50746-2000), Functional safety of electrical/electronic/programmable electronic safety-related systems. Part 1 – Part 7.
- IEC 61000-1-5, (referred in GOST R 50746-2000), High power electromagnetic effects on civilian systems.
- IEC 61000-6-6, Generic standard – High power electromagnetic immunity for indoor equipment.

전자기파 검증의 경우에는 러시아의 기술기준이 구체적으로 시험항목과 시험방법을 IEC의 표준을 중심으로 지정하였다. 따라서 한국의 기술기준인 RG 1.180의 요구항목과 차이를 보이고 있다. 따라서 러시아의 기술기준을 맞추기 위해서는 IEC 61000의 기준에 의거하여 시험을 해야하고 항목별로 시험통과수준를 강화하거나 추가적으로 시험해야 하는 등의 조처가 필요하다. 러시아는 국제전기협회(IEC)에 이 기준들을 협의항목의제 (NWIP, New Working Item for Proposal)로 제안한 상태이므로 원자력발전소만을 위한 IEC 기술기준이

제정되거나 Russia 기술기준이 다소 완화되는 방향으로 변경될 가능성도 존재한다.

3.4. 내진검증기준(IEEE Std 344-1987)에 대한 비교검토

내진검증은 IEEE Std 344 -1987, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for NPPs 에 의거해서 대부분 수행된다. 여기에 해당되는 러시아의 내진검증 관련 표준은

- NP-031-01, " Norms for design of earthquake-proof NPPs"
- GOST 17516.1-90 " Electrical articles. General requirement for environment mechanical stability"
- GOST 16962.2-90 " Electrical articles. Test methods as to environment mechanical factors stability"
- IEC 60980

등이 있다. IEEE Std 344는 충분히 상세하고 구체적인 반면, 러시아 규제요건은 개념적인 상위요건을 기술하고 실행방법은 규정하지 않고 있다. 따라서 IEEE Std 344에 따라 내진 검증을 하고 이 방법과 시험결과가 러시아의 상위 요건과 정의에 부합되는 지를 설명해야 될 것으로 판단된다.

3.5. 내환경검증기준(IEEE Std 323-2003)에 대한 검토

내환경 기기검증은 IEEE Std 323-1984, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations과 이에 해당되는 러시아의 내환경 관련 원자력기기의 기술기준을 검토하였다. 검토한 러시아 기술기준은 다음과 같다.

- GOST 25804.5-83, " Atomic power station technological process control system equipment. General rules of conducting test specimens and serial items test acceptance"
- GOST 25804.7-83, " Atomic power station technological processes control system equipment. Evaluation methods of meeting durability, endurance id resistance requirements for highest influential factors"
- GOSATOMNADZOR of Russia, RB-004-98 " Requirements for certification of control system important for safety of nuclear plants"
- Federal norms and rules in the area on the use of nuclear energy. NP-026-01, 2001, " The requirements to control system important for safety of nuclear stations"
- GOST 29075-91, " Nuclear instrumentation systems for nuclear power stations. General requirements"

러시아의 내환경 검증 기술기준은 시험종류 및 조건 등에 대하여 계통 및 기기

별로 구체적인 시험요건을 포함한 다는 점에서 포괄적으로 기술된 IEEE Std 323 보다 상세하다고 볼 수 있다. 따라서 IEEE Std 323 에 맞게 기기검증을 하였다는 사실이 바로 러시아의 기술기준에 저절로 만족한다고 평가할 수는 없다. 시험결과 및 내용이 러시아의 규제지침에도 적합한지를 분석하여 평가해야 한다.

3.6. 소프트웨어 확인 및 검증(IEEE Std 1012-1998)에 대한 검토

소프트웨어 확인 및 검증은 러시아의 경우 포괄적이고 전문적으로 원전의 디지털 기기에 대한 소프트웨어 확인 및 검증을 수행하기 위한 지침문서가 존재하지 않고 품질보증관련 문서에 포괄적인 요건으로 포함되어 있으므로 표준문서 대 표준문서로 비교할 수는 없다. 관련된 러시아 기술기준 문서들은 다음과 같다.

- IEC 60880-1986 “ Software for Computers in the Safety Systems of Nuclear Power Stations”
- RD-03-34-2000 Gosatomnadzor of Russia regulatory document – “ Requirements to the scope and content of verification and justification report of software used for safety justification of objects of atomic energy use”
- GOST R ISO 9000-2001 “ Quality management systems. Fundamentals and vocabulary”
- GOST R ISO 9001-2001 “ Quality management systems. Requirements”
- GOST R ISO/IEC 12207-99 “ Information technology. Software life cycle processes”

4. 결론

러시아의 원자력 계측제어계통에 대한 기술기준 분석결과 대체적으로 러시아의 기술기준이 IEEE 기술기준과는 기술요건과 체계가 매우 다르게 규정되었음이 발견되었다. 내진설계 기준의 경우에는 IEEE Std 344 에 의거한 기기검증방법이 충분히 러시아의 요건을 만족할 수 있을 것으로 해석되었으나, 전자기파의 경우는 러시아의 기술기준을 만족하기 위해서는 국내에서 적용하는 Regulatory Guidelines 1.180 의 시험항목 외에 추가적인 시험을 해야 하는 것으로 평가되었다. 그러나 충실한 설계와 검증을 통하여 기기의 건전성을 확보하려는 기본개념은 같다. 그럼에도 불구하고 기술기준 체계가 다르기 때문에 어느 한쪽의 기술기준에 맞는 기기나 제어시스템이 자동적으로 다른 쪽의 기술기준에 만족한다고 간주 될 수는 없다. 따라서 한국 및 러시아 중 한쪽에서 만족된 기기를 다른 쪽에서 사용을 하기 위해서는 그 기기의 시험 혹은 설계의 내용을 사안별로 해석하여 양쪽의 기술기준에 합당함을 증명해야 할 것이다.

부록 I

한-러 계측제어 규제요건 검토 :

러시아 원자력시설 사용 인허가 절차

Comparison of the Standards applied to NPP I&C design in Korea and Russia

Regulatory documents and licensing process in the field of the atomic energy use in the Russian Federation

Prepared by developer
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Technical editor
Vladimir Sivokon

Checked by expert
Vladislav Kolinenko

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1. Introduction

1.1. Legislative base of licensing

Licensing of activity in the field of the atomic energy use is one of the integral functions of the State regulation of nuclear and radiation safety.

1.1.2. The purpose of the State regulation of nuclear and radiation safety at atomic energy use is a formation of the conditions at which a protection of atomic energy objects personnel is guaranteed, as well a protection of the population and an environment from inadmissible radiation influence and prevention of uncontrollable distribution and use of nuclear materials.

1.1.3. The legal basis of the State regulation at atomic energy use in the Russian Federation territory is being formed by the international conventions signed by the Russian Federation, Federal laws, administrative documents of the President of the Russian Federation and the Government of the Russian Federation.

1.1.4. In the Russian Federation the licensing (allowing) procedure of activity (works, services) is legislatively established in the field of atomic energy use, see **Fig. 1**.

1.1.5. The Federal law of the Russian Federation **«About an atomic energy use» № 170-FZ dated by 21.11.1995** defines a legal basis and principles of regulation of the attitudes (relations) arising during an atomic energy use.

1.1.6. Legal regulation in the field of radiation safety and the manipulation with radioactive sources is also supervised by the Federal law, in this case it is a law **«About radiation safety of the population» № 3-FZ dated by 01.01.1996.**

N.B. *The relations arising at engineering, adoption, application, execution of obligatory demands and demands on a voluntary basis, to production, processes of execution, operation, storage, carriage, realization and the utilization, works execution or rendering services, and also an estimation of conformity, are adjusted by new* ***Federal law № 184-FZ from December, 27, 2002 «About technical regulation», which has come into force on July, 1, 2003.***

Technical regulation is realized according to the following principles:

- *applications of uniform rules of an establishment of demands to production, processes of execution, operation, storage, carriage, realization and the utilization, works execution or rendering services;*
- *conformity of technical regulation to a level of development of national economy, development of material base, and also to a technological level;*
- *independence of bodies on accrediting, bodies on certification from manufacturers, vendors, executives and purchasers;*
- *uniform system and rules of accrediting;*
- *uniform rules and methods of tests and measurements at conducting procedures of an obligatory estimation of conformity;*
- *unification of application of Technical order demands irrespective of kinds or peculiarities of the deals;*
- *impermissibility of competition limitation at accomplishment of accrediting and certification;*
- *impermissibility of overlapping of authorities of body of the State supervision and body on certification;*

- *impermissibility of overlapping by one body of authorities on accrediting and certification;*
- *impermissibility of inappropriate (not from the budget) financing of the State supervision of compliance with the demands of Technical orders.*

Before adoption of the common Technical order on nuclear and radiating safety the technical regulation in the field of nuclear and radiating safety is realized in accordance with the Federal laws «About an atomic energy use» and «About radiation safety of the population» *(Article 46, item 6 of the Federal law «About technical regulation»).*

According to Article 46, item 7 of the Federal law «About technical regulation» ***the Technical orders should be developed and accepted within seven years from the date of entry of this law into force*** *(till July, 1, 2010).*

1.1.7. Legal regulation in the field of fire safety is carried out by the Federal law **«About fire safety » № 69-FZ dated by 21.12.1994.**

1.1.8. Legal regulation in the field of industrial safety is carried out by the Federal law **«About industrial safety of dangerous industrial objects » № 116-FZ dated by 21.07.1997.**

NB: There is also another Federal law named «About licensing particular types of activities» 128-FZ dated by 08.09.2001, but it is not valid for activities in the field of atomic energy use.

1.1.9. The primary goals of legal regulation of the attitudes arising at realization of all kinds of activity in the field of atomic energy use, are the following:

- Creation of legal bases of the governmental management system in the field of the atomic energy use and a system of State regulation of safety at atomic energy use;
- Establishment of the rights, duties and the responsibilities of governmental bodies, institutions of regional government, the organizations and other legal persons and citizens.

1.1.10. Objects of application of the Federal law «About an atomic energy use» (Article 3) are the following (shown in Fig. 2):

- nuclear installations;
- radiation sources;
- points of the nuclear materials and radioactive substances storage, storages of radioactive waste products;
- fuel assemblies of the nuclear reactor;
- spend fuel assemblies of the nuclear reactor;
- nuclear materials;
- radioactive substances; radioactive waste products.

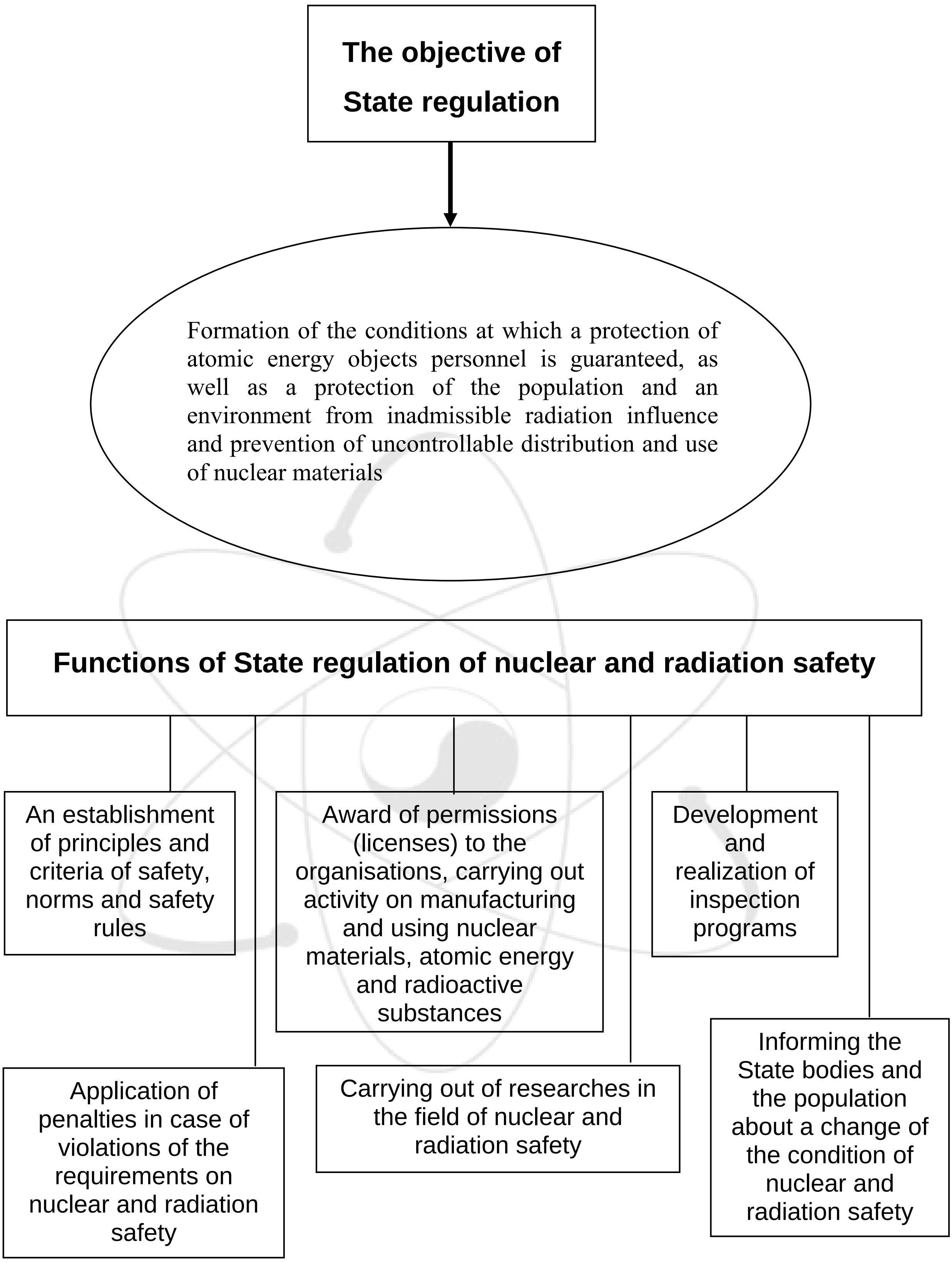

Fig. 1 Objective and functions of State regulation of nuclear and radiation safety

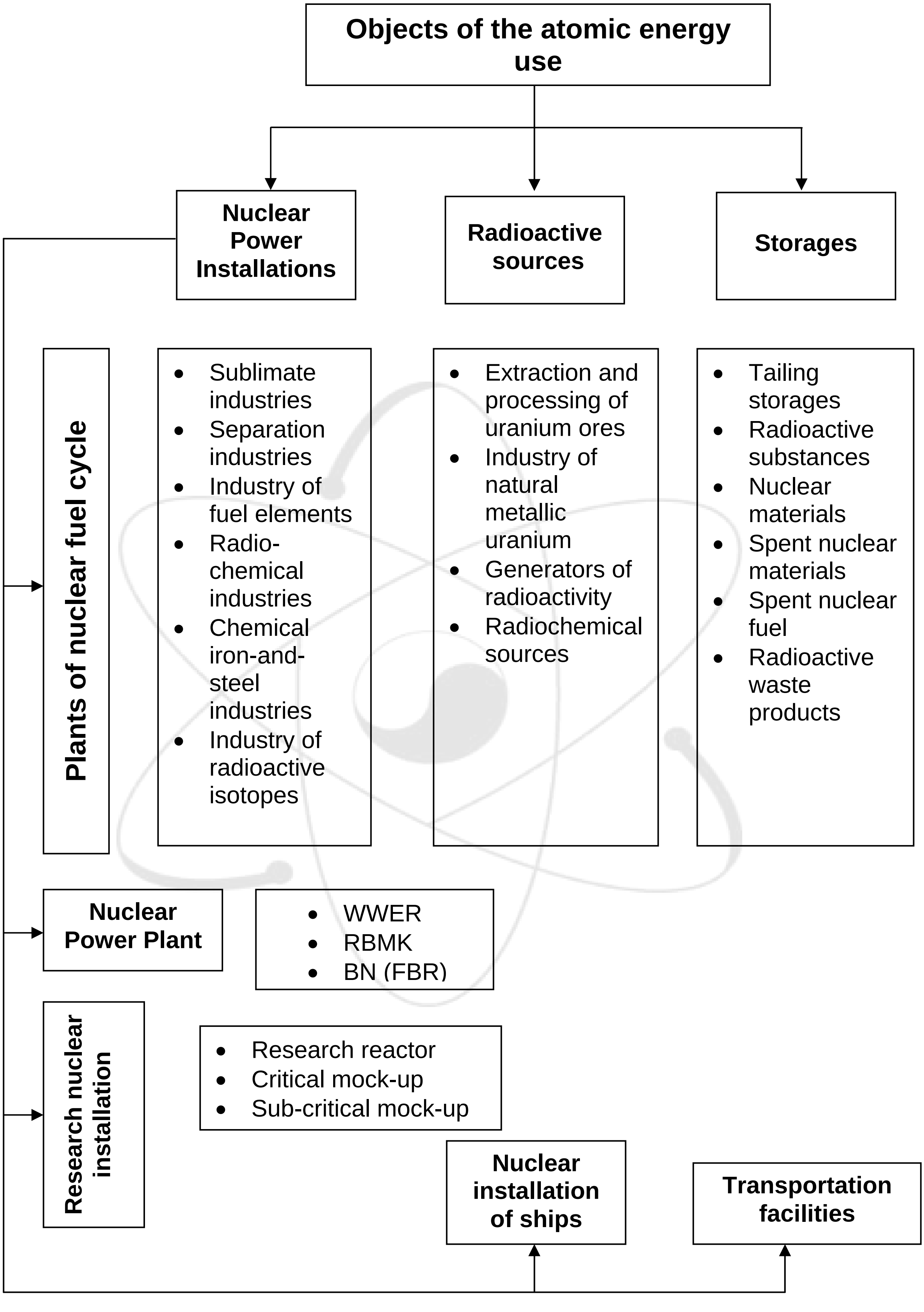

Fig. 2 Objects of the atomic energy use to which the system of regulatory documents is applied

1.1.11. According to the Federal law «About an atomic energy use» any activity in the field of atomic energy use, which is a subject for licensing by state bodies of the safety regulation, is not allowed without the permission (license) for its carrying out. In Appendix №1 several kinds of activity are listed on which conduction the licenses are required in the field of the atomic energy use.

1.1.12. According to the Federal law «About radiation safety of the population» works in the field of the manipulation with radioactive sources, including design, construction, design of sources, and also works in the field of extraction, manufacture, transportation, storage, use and siting storages of radioactive sources are carried out only on the basis of the special permissions (licenses) given by bodies, authorized on conducting licensing.

1.1.13. According to the Federal law «About industrial safety of dangerous industrial objects» activity on design, construction, operation, manufacturing and repair of the technical equipment used on a dangerous industrial object, carrying out of industrial safety examination can be done on the basis corresponding to the license given by Federal regulatory authority, specially nominated for the field of industrial safety.

1.1.14. According to the Federal law «About fire safety» any activity (works, services) in the field of fire safety is carried out on the basis of the licenses, which are given out by the State fire-prevention service.

1.1.15. Only those legal persons who have licenses of GOSATOMNADZOR of Russia have the right in territory of the Russian Federation to be engaged in activity on manufacture and/or use of nuclear materials, an atomic energy, radioactive substances and products on their basis, and also to make, own and use any installations with nuclear materials and radioactive substances in commercial and noncommercial purposes. Structure of GOSATOMNADZOR of Russia is shown in **Fig. 3**.

1.1.16. According to Article 27 of the Federal law «About an atomic energy use» a performance of the certain kinds of activity in the field of the atomic energy use is carried out by personnel of the objects of the atomic energy use which have the permissions, given out by the State bodies of the safety regulation. The list of experts defining the staff members who (depending on activity carried out by them) should receive the right of conducting works in the field of the atomic energy use is defined by the Government of the Russian Federation.

1.1.17. According to Article 37 of the Federal law «About an atomic energy use» the equipment, products and technologies for nuclear installations, radiation sources or points of storage are subject to obligatory certification according to the legislation of the Russian Federation. Requirements about obligatory certification of the technical equipment used on dangerous industrial object are determined by Article 7 of the Federal law «About industrial safety of dangerous industrial objects». Article 33 of the Federal law “About fire safety” defines similar requirements about obligatory certification of production and services in the field of fire safety.

1.1.19. Infringement by officials or citizens of the legislation of the Russian Federation in the field of the atomic energy use entails the disciplinary, administrative or the criminal liability according to the legislation of the Russian Federation.

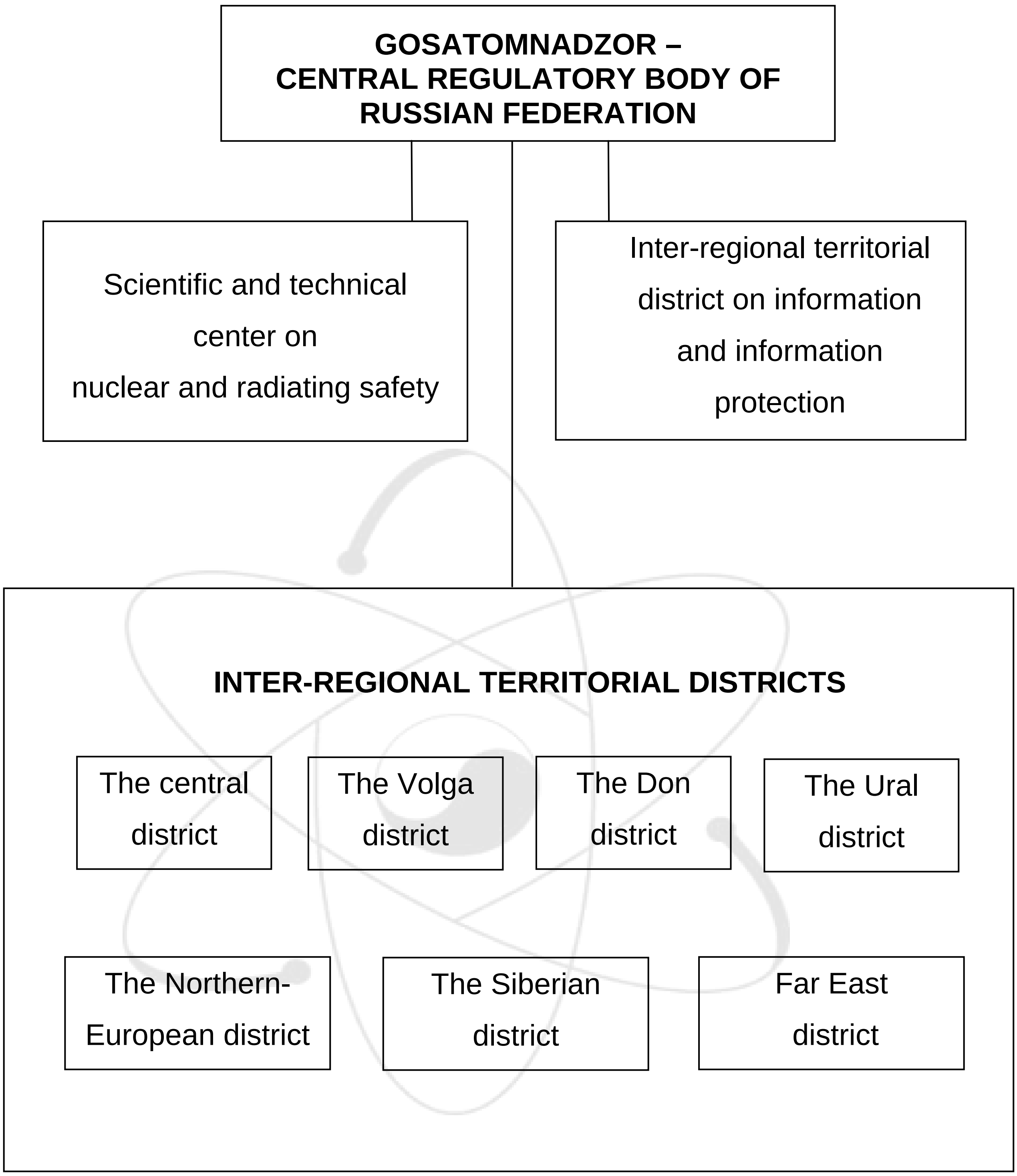

Fig. 3 Structure of Russian Regulatory Body (GOSATOMNADZOR)

1.2. Some terms and definitions

1.2.1. The permission (license) to the right of conducting works in the field of the atomic energy use is properly made out document confirming the right on realization of a certain kind of activity under condition of a safety provisions of objects of the atomic energy use and works (the Federal law «About atomic energy use», Article 26).

1.2.2. Examination (expertise) of safety is a scientific and technical estimation of the object safety or the safety of declared kind of the activity, being conducted by the analysis of Applicant's documents proving nuclear and radiation safety (further a substantiation of safety), design, technical and organizational decisions on conformity to requirements of regulatory documents and to the achieved level of development of a science and techniques.

1.2.3. Result of examination of safety is the Conclusion of the expert organization presented to GOSATOMNADZOR of Russia or its inter-regional territorial bodies, see Fig.2.

1.2.4. Industrial safety of dangerous industrial objects is a condition of security of the vital interests of the person and a society from accidents on dangerous industrial objects and consequences of these accidents (the Federal law «About industrial safety of dangerous industrial objects», Article 1).

1.2.5. Technical regulation is a legal regulation of attitudes in the field of an establishment, applications and executions of obligatory requirements to production, processes of manufacture, operation, storage, transportation, realization and recycling, and also in the field of an establishment and application on a voluntary basis of requirements to production, processes of manufacture, operation, storage, transportation, realization and recycling, performance of works or rendering of services and legal regulation of attitudes in the field of an estimation of conformity (the Federal law «About technical regulation», Article 2).

1.2.6. The Technical order is the document which is accepted by the international treaty ratified by the Russian Federation in the order, established by the legislation of the Russian Federation, either the Russian Federal law, or the decree of the President of the Russian Federation, or the decision of the Government of the Russian Federation and establishes obligatory requirements for application to objects of technical regulation (production, including buildings, structures and constructions, processes of manufacture, operation, storage, transportation and recycling) (the Federal law «About Technical regulation», Article 2).

1.2.7. The certificate of conformity is the document certifying conformity of the object to requirements of technical rules, to positions of standards or contracts conditions (the Federal law «About Technical regulation», Article 2).

1.2.8. The declaration on conformity is the document certifying conformity of the production released in the manipulation to requirements of the technical specification (the Federal law «About Technical regulation», Article 2).

1.2.9. The following objects concern to a category of dangerous industrial objects:

- the equipment working under pressure more 0,07 MPa or at temperature of water heated more than 115 degrees;
- the equipment which contains permanently established load-lifting mechanisms, escalators, cable roads, cable cars are (the Federal law «About industrial safety of dangerous industrial objects», the Appendix №1).

2. State regulation of safety at atomic energy use

2.1. According to Articles 23, 24 of Federal law **«About an atomic energy use»** the State regulation of safety at atomic energy use is carried out by specially authorized Federal enforcement authorities.

2.2. The Federal supervision of Russia on nuclear and radiation safety (GOSATOMNADZOR of Russia) has been appointed by the decision of the Government of the Russian Federation (№ 265 from 22.04.2002) as the Federal enforcement authority which is carrying out state regulation of nuclear and radiation safety at atomic energy use in the peaceful purposes..

2.3. According to the Decree of the President of the Russian Federation from January, 21, 1997 N 26, bodies of State regulation of nuclear, radiation, technical and fire safety at atomic energy use also are:

- Federal Mining and Industrial Supervision of the Russian Federation;
- Ministry of Health of the Russian Federation;
- The Ministry of Internal Affairs of the Russian Federation (the State fire-prevention service).

(Later, by the Decree of the President of the Russian Federation № 1309 from November, 9, 2001, the State fire-prevention services has been transferred to the Ministry for the Russian Federation on Emergency Situations).

2.4. Bodies of State regulation of nuclear, radiation, technical and fire safety are independent of the other State bodies, and also from the organizations which activity is relevant to atomic energy use.

Kinds of activity in the field of regulation of nuclear, radiation, technical and fire safety and differentiation of powers, the rights, duties and the responsibility of corresponding bodies, and also power of officials of the specified bodies are established in the State documents about bodies of State regulation of safety.

2.5. According to Article 25 of the Federal law «About an atomic energy use» an activity of bodies of state regulation of nuclear, radiation, technical and fire safety is directed on the organization of development and the statement of norms and rules to areas on safety, distribution of permissions/licenses for the right of conducting works in the field of atomic energy use, realization of supervision of safety, carrying out of examination and inspections, the control over development and realization of actions on protection of workers of objects of atomic energy use, the population and preservation of the environment in case of accident at atomic energy use.

3. Federal regulatory body of Russia on nuclear and radiation safety (GOSATOMNADZOR of Russia)

3.1. GOSATOMNADZOR of Russia carries out the activity (directly or through the territorial bodies), cooperates with other Federal enforcement authorities, enforcement authorities of subjects of the Russian Federation and institutions of local government.

3.2. GOSATOMNADZOR of Russia on the basis of the legal acts of the Russian Federation carries out in territory of the Russian Federation the State regulation of nuclear and radiation safety during manufacture and use of nuclear materials, an atomic energy and radioactive substances in the peaceful purposes in the way:

- establishments of criteria of safety, norms and rules on safety, and also other regulating influences;
- the organization of development of licensing procedures and licenses issue to the legal and natural persons who are carrying out an activity on manufacture and use of nuclear materials, an atomic energy and radioactive substances;
- development and realization of inspection programs on all installations of commercial and noncommercial purpose making or using nuclear materials and –or an atomic energy;
- application of sanctions in case of infringement of requirements on nuclear and radiation safety;
- maintenance, and also carrying out of independent researches on nuclear and radiation safety;
- informing of the State bodies and the population about change of a condition of nuclear and radiation safety.

3.3. GOSATOMNADZOR of Russia estimates safety of the objects of atomic energy use independently from the Utilities.

3.4. Differentiation of powers of GOSATOMNADZOR of Russia and its regional bodies on licensing for kinds of activity is given in Appendix №3.

The competence of the central body of GOSATOMNADZOR of Russia includes licensing activity on a construction, operation and decommissioning the most potentially dangerous objects of atomic energy use.

Licensing of activity on a construction, operation and decommissioning of other objects is referred to the competence of inter-regional territorial bodies of GOSATOMNADZOR of Russia.

3.5. GOSATOMNADZOR of Russia at introduction of the licensing system in the field of atomic energy use has done the following works:

- developed of the complex of the regulatory documents establishing the requirements to structure of complete sets of documents, regulating nuclear and radiation safety of licensed kinds of activity and objects of their application, and also the contents of these documents;
- differentiated powers on licensing between the central body and inter-regional territorial bodies of GOSATOMNADZOR of Russia;
- authorized divisions of GOSATOMNADZOR of Russia, responsible for realization of license procedures and the persons accepting the decisions on licensing.

4. The organizations which are carrying out the State supervision and activity in the field of atomic energy use

4.1. The supervision in the field of providing radiation safety is carried out by the Government of the Russian Federation, specially authorized Federal enforcement authorities, and also enforcement authorities of subjects of the Russian Federation

4.2. The Federal enforcement authorities allocated by powers on realization of the government of atomic energy use and their competence are established according to Article 20 of the Federal law "About an atomic energy use".

According to existing (by March, 1, 2004) structure of the Government of Russia the Federal enforcement authorities, which are carrying out the State supervision of atomic energy use, are:

- The Ministry for the Russian Federation on an Atomic Energy;
- The Ministry of Internal Affairs of the Russian Federation (fire safety);
- The Ministry for the Russian Federation on Affairs of a Civil Defense, Emergency Situations and Elimination of Consequences of Natural Disasters;
- The Ministry for Transport of the Russian Federation (ships with nuclear installations and radiation sources);
- Ministry of Health of the Russian Federation;
- The State Committee of the Russian Federation on Standardization, Metrology and Certification;
- Federal Service of Russia on Hydrometeorology and Monitoring of an Environment;
- The Ministry of Defense of the Russian Federation (the nuclear weapon and nuclear installations of military purpose).

4.3. The Utility’s power, responsibility and duties on providing safety of nuclear installation, a radiation source and point of storage is established by Articles 34 and 35 of the Federal law «About an atomic energy use».

5. The description of licensing process (regarding GOSATOMNADZOR of Russia)

The diagram of licensing process and procedure (further - just procedure) is submitted in **Fig. 4**.

5.1. Licensing activity in the field of atomic energy use includes:

- consideration of the application for licensing and carrying out of preliminary check of the documents submitted for reception of the license;
- consideration of the declared activity and/or the documents submitted for reception of the license, including the complete set of the documents proving the provisions of nuclear and radiation safety of nuclear installation, a radiation source, and also point of storage of nuclear materials and/or radioactive substances, storages of radioactive waste;
- decision-making on distribution or on refusal in licensing;
- licensing with an establishment of conditions of its action;
- support of the given license by carrying out of inspections with the purpose of check of performance of conditions of the license action, and also by introduction of necessary changes into conditions of the license action;
- change (prolongation) of validity of the license, keeping or cancellation of the license

5.2. The allowing principle at realization of activity in the field of atomic energy use is legislatively fixed in the Federal law «About an atomic energy use».

5.3. According to article 26 of the Federal law «About an atomic energy use» the Government of the Russian Federation has ratified the «**Regulation about licensing of activity in the field of atomic energy use»** (Decision № 865 from 14.07.1997)**.**

The Regulation establishes the order and conditions of licensing of activity in the field of atomic energy use.

It defines:

- procedure of licensing;
- the list of the documents necessary for reception of the license;
- kinds of activity on which performance the license is necessary;
- the order of decision-making on license issue or refusal;
- payment for given out licenses.

It is not distributed on:

- the activity related to development, manufacturing, test, operation, storage and recycling of the nuclear weapon and nuclear power installations of military purpose;
- licensing of medical radiopharmaceutical preparations, distribution of medical permissions (sanitary passports) on the right of work with radiation sources, distribution of the conclusions about a state of health of personnel of objects of atomic energy use, activity on professional selection of the personnel;
- licensing of activity (works, services) in the field of fire safety on objects of atomic energy use.

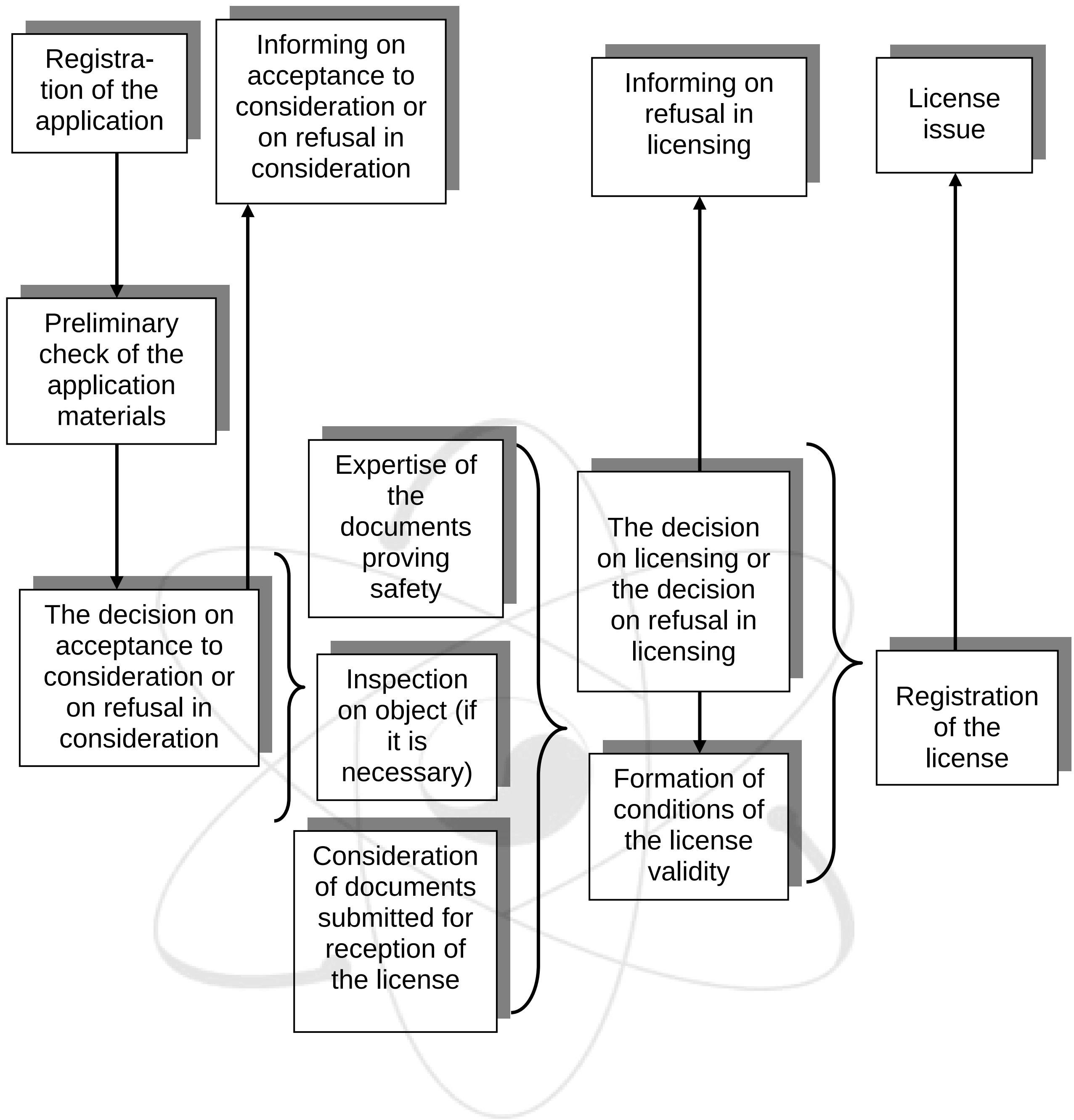

Fig. 4. Licensing procedure of the Russian Regulatory Body (GOSATOMNADZOR)

5.4. Licensing activity in the field of atomic energy use is being carried out by GOSATOMNADZOR of Russia.

5.5. GOSATOMNADZOR of Russia also carries out the State supervision of following licenses action conditions by the Licensee. In case of violence of conditions of licenses action GOSATOMNADZOR of Russia applies the sanctions established by the legislation of the Russian Federation

5.6. GOSATOMNADZOR of Russia gives out licenses for kinds of activity in the field of atomic energy use in accordance with the list shown in Appendix №1.

5.7. The list of licenses for kinds of activity in the field of use of the atomic energy, given out by GOSATOMNADZOR of Russia is listed in Appendix №2.

5.8. Differentiation of licensing powers of GOSATOMNADZOR of Russia and its regional bodies on licensing is specified in Appendix №3 for kinds of activity.

5.9. The license is given out for the term of not less than 3 years. The short term license is also possible incase when the organizations or the persons have addressed for such license.

5.10. Conditions of action the licenses including the requirements of GOSATOMNADZOR of Russia on safety of the licensed kind of activity are an integral part of the license.

5.11. Licenses are given out to the Utilities, and also the organizations carrying out works and giving services in the field of atomic energy use (further called - Applicants).

5.12. The license subscribes by the head of GOSATOMNADZOR of Russia or its regional body authorized by GOSATOMNADZOR of Russia to give out the license for particular kinds of activity.

5.13. For license reception the Applicant represents to GOSATOMNADZOR of Russia or its regional body, authorized to give out licenses for separate kinds of activity, the following:

- the application for licensing with the indication of the name, the organizational - legal form, the legal address, number of the settlement account and corresponding bank, a kind of activity and object of its application, and also validity of the license;
- copies of constituent documents (with presentation of originals if they are not certified by the notary);
- copy of the document confirming the fact of entering of record about the legal person in the Uniform State register of legal persons;
- the information of the tax body on statement on the account;
- copy of the document (made out in proper order), confirming the right of the Applicant to own or use nuclear materials, nuclear installations, radiation sources, points of storage, radioactive substances, radioactive waste products;
- copies of decisions on questions of location, a construction or decommissioning of nuclear installations, radiation sources or the points of storage accepted by corresponding Federal enforcement authorities, bodies of the government of subjects of the Russian Federation or institutions of local government;
- 3 complete sets of the documents proving nuclear and radiation safety of nuclear installation, a radiation source, point of storage and/or the declared activity (requirements to the structure of this complete set of documents and documents contents are defined by GOSATOMNADZOR of Russia);

- the document confirming a payment made for consideration of the licensing application.

5.14. In case when the Applicant is the Utility, except for above listed set, it should be submitted also:

- the document confirming a recognition by corresponding atomic energy authority of suitability of the Applicant to operate nuclear installation, radiation source or point of storage and to carry out by own forces or with attraction of other organizations an activity on siting (site selection), designing, erecting, operation and decommissioning of nuclear installation, a radiation source or point of storage, and also activity under the manipulation with nuclear materials and radioactive substances;
- the document determining reference of object, on which and/or concerning which the declared activity should be carried out, to the categories stipulated by Article 3 of the Federal law “About an atomic energy use";
- the conclusion of the State ecological examination;
- copy of the sanitary passport or other allowing document of bodies of sanitary-and-epidemiologic supervision on the right to work with radiation sources;
- the documents confirming the Applicant financial capability to carry the civil-law responsibility for possible losses and harm, caused by radiation influence stipulated in legislation of the Russian Federation;
- the document confirming capability of the Applicant to transfer for storage the radioactive waste produced or being temporary stored;
- the report on fire-prevention protection of object of atomic energy use during its operation for nuclear plants and other objects determined by Federal norms and rules in the field of atomic energy use;
- the documents confirming presence at the Applicant of financing sources for works on decommissioning of nuclear installations, radiation sources or points of storage, including special fund for financing the expenses related to decommissioning of the specified objects, and for financing the research and developmental works on a substantiation and increase of safety of these objects.

5.15. The documents proving nuclear and radiation safety of nuclear installation, point of storage, a radiation source, at the moment of submission of the application on reception of the license should reflect all changes which have occurred on object of atomic energy use in the design, operational and technological documentation. The specified documents should be made out when in due order and not have the delayed validities.

5.16. At revealing unknown circumstances relevant to safety of the licensed kind of activity, at introduction in action of new Federal norms and rules in the field of atomic energy use or at the manipulation of the Licensee with the application for change of conditions of action of the license, the GOSATOMNADZOR of Russia can request from the Licensee a presentation of the additional documents proving safety of the licensed kind of activity, and to make the decision on modification in the license.

5.17. It is forbidden to demand from the Applicant a presentation of the documents which have not been not stipulated in «Regulations about licensing of activity in the field of atomic energy use».

5.18. Duration of consideration of the application, including preliminary check of the nomenclature of documents and compliance to the established rules of their registration, should not exceed 15 days from the date of the document registration, submitted for reception of the license.

5.19. By results of preliminary check it is made a decision on acceptance of the documents submitted for reception of the license, to consideration or the decision on refusal in consideration of these documents, confirmed by the authorized officials of GOSATOMNADZOR of Russia.

In case of refusal in consideration of the documents submitted for reception of the license, the proved reason of refusal is underlined in the notice.

5.20. During consideration of the documents submitted for license reception, GOSATOMNADZOR of Russia organizes a check of reliability of the data contained in documents, examination of the documents proving nuclear and radiation safety of nuclear installation, a radiation source, point of storage and/or the declared activity, if necessary carries out inspections on objects of the Applicant, cooperates with the Applicant on questions of elimination of the revealed lacks.

5.21. During consideration of the complete set of the documents proving nuclear and radiation safety of nuclear installation, a radiation source, point of storage and/or the declared activity, GOSATOMNADZOR of Russia necessarily analyzes:

- conformity of design and technological decisions to Federal norms and rules in the field of atomic energy use, qualification of personnel to the established requirements and presence of conditions for its maintenance at a necessary level, and also presence and conformity to the established requirements to the system of gathering, storage, processing and storing radioactive waste products at realization of the declared activity;
- completeness of measures of technical and organizational character on providing nuclear and radiation safety at realization of the declared activity;
- corresponding (required) conditions of storage and the organization of the account and the control of nuclear materials, radioactive substances, maintenance of physical protection of nuclear installations, radiation sources, points of storage, nuclear materials and radioactive substances, plans of measures on protection of workers of object of atomic energy use and the population in case of occurrence of accident and readiness for their performance, and also systems of maintenance of quality and necessary technical-engineering support of the declared activity;
- ability of the Applicant to provide a condition of the safe termination of the declared activity and decommissioning of object of atomic energy use, and also presence of corresponding design materials.

5.22. The decision on distribution or on refusal in licensing is accepted by officials of GOSATOMNADZOR of Russia in time no more than 30 days from the date of end of examination of the documents proving nuclear and radiation safety of nuclear installation, a radiation source, point of storage and/or the declared activity.

5.23. As it was mentioned above, at refusal in licensing the proved reason of refusal should be underlined in the notice.

The basis for refusal in licensing is:

- presence in the documents submitted for reception of the license any doubtful or false information;
- the expert conclusion which has established insufficient proving of nuclear and radiation safety of nuclear installation, radiation source, point of storage and/or the declared activity;
- discrepancy of the declared activity to requirements on providing nuclear and radiation

safety.

5.24. The license is made out by GOSATOMNADZOR of Russia in time no more than 20 days from the date of decision-making on its issue.

5.25. GOSATOMNADZOR of Russia can deprive with the Licensee of the right of realization of a kind of activity stipulated in the license, having suspended the license or having cancelled it.

The basis for the deprivation of the Licensee of the right of realization of a kind of activity stipulated in the license, is:

- infringement by the Licensee of Federal laws and other normative legal acts of the Russian Federation in the field of atomic energy use;
- detection of a false information in the documents submitted for reception of the license;
- infringement by the Licensee of conditions of action of the license;
- default by the Licensee of instructions of GOSATOMNADZOR of Russia or other bodies of State regulation of safety at atomic energy use;
- default by the Licensee of instructions or orders of the State bodies or suspending by them of the Licensee activity according to the legislation of the Russian Federation;
- submission by the Licensee of the corresponding application.

5.26. The motivated decision of GOSATOMNADZOR of Russia on suspending action of the license or its cancellation is possible up to the Licensee in writing not later than the date from which action of the license is suspended or cancelled.

5.27. GOSATOMNADZOR of Russia in 3-day's term from the date of decision-making on suspending action of the license or its cancellation informs on the decision accepted by it:

- the corresponding enforcement authority which has confirmed the right of the Licensee to own or use nuclear materials, nuclear installations, radiation sources, points of storage, radioactive substances, radioactive waste products;
- corresponding body of the State tax service of the Russian Federation;
- corresponding bodies of State regulation of safety at atomic energy use.

If the Licensee is the Utility, GOSATOMNADZOR of Russia also informs on the accepted decision the authority in atomic energy use, recognized this organization suitable to operate nuclear installation, a radiation source or point of storage and to carry out by own forces or with attraction of other organizations activity on siting, designing, construction, operation and decommissioning of nuclear installation, a radiation source or point of storage, and also activity under the manipulation with nuclear materials and radioactive substances.

5.28. In case of suspending action of the license the Licensee is obliged to stop carrying out the kind of activity allowed by this license.

In case of change of the circumstances, which have entailed suspending action of the license, the action of the license can be renewed.

The license is considered renewed after acceptance of the corresponding decision by GOSATOMNADZOR of Russia on what it informs (in 3-day's term from the date of acceptance) the Licensee and bodies to which the information on suspending action of the license was sent.

5.29. In case of cancellation of the license the Licensee is obliged to stop to carrying out the kind of activity allowed by this license and to return the license in GOSATOMNADZOR of Russia.

5.30. At liquidation of the Licensee as a legal person the license given to it loses a validity.

5.31. By reorganization or change of the name of the legal person the Licensee is obliged to submit the application to GOSATOMNADZOR of Russia about renewal of the license in 15-day's term from the date of registration in proper order to reorganization or changes of the name. Renewal of the license is made in the order established for reception of the license.

Before renewal of the license or acceptance of the motivated decision by GOSATOMNADZOR of Russia about refusal in renewal and cancellation before the given license the Licensee carries out activity on the basis of before given license.

At renewal of the license, the earlier given license is cancelled and is subject to return to GOSATOMNADZOR of Russia.

5.32. Consideration of applications for licensing and license issue are carried out for the payment.

The next payments are established, for example:

- for consideration of applications for licensing and about change of conditions of licenses - in the 3-fold size of the minimal size of a payment established by the law in Russian. Federation;
- for licensing for designing and designing of nuclear installations, radiation sources, points of storage - in the 75-fold size of the minimal size of a payment established by the law;
- for licensing for designing and manufacturing of the equipment for nuclear installations, radiation sources, points of storage - in the 50-fold size of the minimal size of a payment established by the law;
- for licensing for carrying out of examination of the design, technological documentation and the documents proving of nuclear and radiation safety of nuclear installations, radiation sources, points of storage, activity under the manipulation with nuclear materials, radioactive substances, radioactive waste products, - in the 25-fold size of the minimal size of a payment established by the law;

5.33. The charges suffered by the Applicant or the Licensee in connection with carrying out of examination of documents, proving nuclear and radiation safety, audit of the documents represented for reception of the license or for modification in conditions of action of the license, and also charges on carrying out of inspections and the inspections which are carried out by the expert organizations or expert under contracts with the Applicant or the Licensee, are not included in the fixed payment for consideration of applications for licensing and in the payment for the licensing specified in the previous item.

5.34. In case of default in consideration of the documents submitted for reception of the license, by results of preliminary check or refusal in licensing the payment for consideration of the application for licensing to the Applicant does not come back.

5.35. Modification in conditions of action of the license can be caused by the following reasons:

- changes of the design, operational and technological documentation which do not demand a performance of works on reconstruction or modernization on the power unit;
- changes of the design, design, operational and technological documentation which demand a performance of works on reconstruction or modernization on the power unit;
- updating of the organizational - engineering specifications (the actions compensating deviations from the reference document, the program of works on elimination of deviations from the reference document, schedules of works, etc.);
- updating of terms of performance of requirements of conditions of action of the license;

- commissioning of new regulatory documents;
- recommendations of the commission on investigation of the event causes on object of the atomic energy use.

5.36. The complete set of documents for modification of the license action conditions should obligatory include:

- the materials which are revealing in detail the reasons of modifying, the description of suggested changes, the analysis of influence of suggested changes on safety and a substantiation of nuclear and radiation safety of examined object;
- the project of the notice made about change of the design, operational and technological documentation (if it is required for change of conditions of the license action);
- the list of the documentation to which the modification caused by suggested changes should be made;
- description of suggested changes of conditions of action of the license.

5.37. If a result of change of the design, operational and technological documentation on object of the atomic energy use requires works on reconstruction or modernizations, in the complete set of represented documents should be included the following documents:

- organizational - technical materials proving the necessity of modification (the decision, orders, schedules, etc.);
- the design documentation (additions in “the Technical substantiation of safety...”, technical projects, specifications, certificates, etc.);
- the technological documentation (programs, etc.);
- the operational documentation.

6. The organization and carrying out of examination (expertise) of documents

Examination of documents is carried out with the expert organizations having the corresponding license for carrying out of examination, by expenses of the Utility or the organization supposing operation of object.

Result of realization of documents examination is the Conclusion.

At the organization of documents examination the order is established which provides strict following a principle of independence of examination:

- the expert can not participate in the development of the documents submitted for examination;
- the expert should not show prejudiced interest or have other preconditions interfering objectivity of the examination results.

6.1. The organization and carrying out of examination on nuclear and radiation safety initiated by GOSATOMNADZOR of Russia

6.1.1. With the purpose of the safety examination regulation GOSATOMNADZOR of Russia has commissioned two regulatory documents:

- «Regulations about the order of carrying out of examination of the documents proving nuclear and radiation safety of nuclear installation, a radiation source, point of storage and/or quality of the declared activity. RD-03-13-99».
- «Requirements to structure and the contents of the documents confirming ability of the organization to carry out examination of documents on a substantiation of safety at atomic energy use and/or quality of declared activity. RD-03-39-98».

6.1.2. GOSATOMNADZOR of Russia carries out management of system of examination of safety by means of:

- the organization of development and approval of regulatory documents, harmonization of requirements of norms and rules in the field of atomic energy use;
- development and approval of the regulatory documents used at the organization and carrying out of examination of safety;
- distribution to the expert organizations of the license for carrying out of examination;
- the control of following regulatory requirements documents on the organization and carrying out of safety examination;

6.1.3. In full conformity with the concept of "defense in depth", the following shall be comprehensively analyzed at examination of safety:

- readiness of the Utility to operate the object according to requirements of effective standards and rules in the field of atomic energy use;
- sufficiency of the stipulated measures under the prevention and development of accidents;
- safety of the declared kind of activity, modes of normal operation and transient modes of object operation;
- safety of the declared kind of activity or object at accidents and the consequences related to them;

- sufficiency of systems of safety and other measures stipulated for accident prevention, localization and elimination of their consequences.

6.1.4. According to requirements of regulatory documents the decision on necessity of carrying out of examination of documents, its subjects and volume is made by responsible division of GOSATOMNADZOR of Russia, directing the application for carrying out of examination in the expert organization.

6.1.5. The expert organization develops the Technical specification on the organization and carrying out of examination (in time 30 days from the date of reception of documents of the Applicant) which is agreed by the responsible person from GOSATOMNADZOR of Russia.

6.1.6. By results of examination the expert organization develops the Conclusion which is approved and sent to GOSATOMNADZOR of Russia.

6.1.7. Examination is considered being completed after acceptance of the Conclusion of the expert organization by responsible division of GOSATOMNADZOR of Russia.

6.1.8. The responsible division of GOSATOMNADZOR of Russia estimates the Conclusion of the expert organization (in time no more than 30 days from the date of reception) on conformity to requirements of the Technical specification.

6.1.9. Examination is carried out according to requirements of the document «System of a quality management. Requirements» (GOST R ISO 9001-2001), its logic diagram is shown in **Fig. 5**.

6.2. The organization and carrying out of ecological examination

6.2.1. The order of carrying out of the State ecological examination is determined in Article 14 of the Federal law № 174-FZ «About ecological examination».

6.2.2. Objects of the State ecological examination of the Federal level are determined by Article 11 of the Federal law «About ecological examination».

6.2.3. Ecological examination is based on the following principles:

- presumptions of potential ecological danger of any planned economic and other activity;
- compulsions of carrying out of the State ecological examination before decision-making on realization of object of ecological examination;
- integrated approach of an estimation of influence on environment of economic and other activity and its consequences;
- compulsions of the account of requirements of ecological safety at carrying out of ecological examination;
- reliability and completeness of the information presented for ecological examination;
- independence of ecological examination experts at realization of their duty in the field of ecological examination;
- scientific validity, objectivity and legality of the conclusions of ecological examination.

6.3. The organization and carrying out of examination of technical means

According to Article 13 of the Federal law «About industrial safety of dangerous industrial objects» (№ 116-FZ from 21.07.1997), the following are subjects of industrial safety expertise:

- the design documentation on construction, expansion, reconstruction, modernization, preservation and liquidation of dangerous industrial object;
- the technical means used on dangerous industrial object;
- buildings and constructions on dangerous industrial object;
- the declaration of industrial safety and other documents relevant to operation of dangerous industrial object .

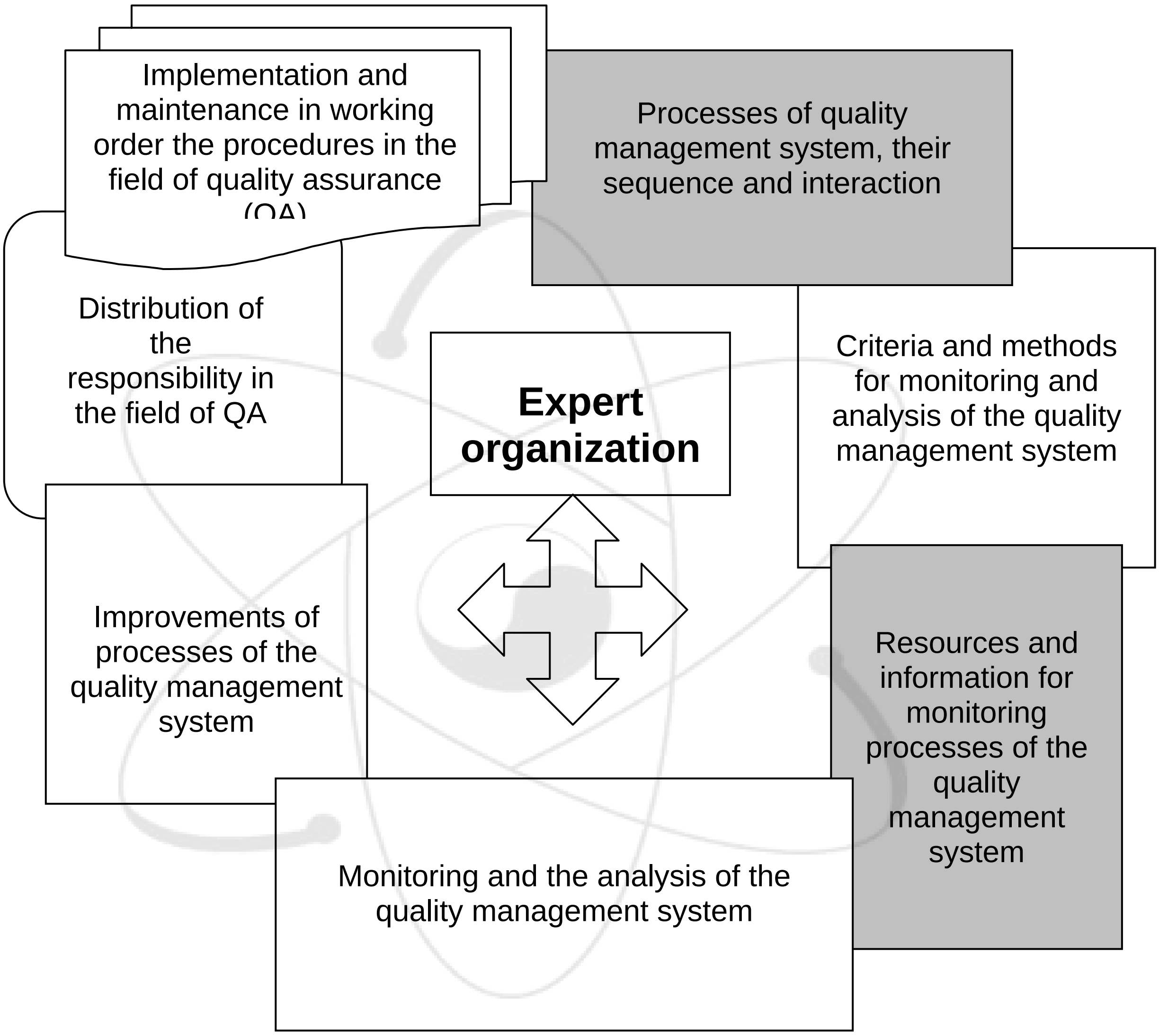

Fig. 5. General provisions of qulitiy management system at the expert organization

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7. Requirements to structure of the complete set and the contents of the documents proving nuclear and radiation safety and presented for reception of licenses for kinds of activity in the field of the atomic energy use

7.1. GOSATOMNADZOR of Russia has established **Requirements** to the structure and the contents of complete set of the documents proving nuclear and radiation safety at reception of the license for the following kinds of activity (a selection relevant to the NPP is listed):

- siting the NPP Unit, storages of nuclear fuel, storages of radioactive waste products and a radiation source;
- siting nuclear thermal power station of low power on the basis of the floating Unit;
- construction of the NPP Unit;
- construction of nuclear thermal power station of low power on the basis of the floating Unit;
- construction of the NPP Unit which construction is not completed at the moment of introduction of the present Requirements;
- operation of the Unit after commissioning;
- operation of the nuclear thermal power station of low power on the basis of the floating Unit after commissioning;
- operation of the working NPP Unit;
- operation of the NPP Unit after shut down for decommissioning;
- decommissioning of the NPP Unit;
- use of nuclear materials and radioactive substances at carrying out of research and developmental works on the NPP;
- designing of the NPP Unit, nuclear thermal power station of low power on the basis of the floating Unit, storages of nuclear materials, radioactive waste products and radiation sources;

7.2. Structure of the complete set of documents for reception of the license for set above kinds of activity is specified in the document of GOSATOMNADZOR of Russia named «Requirements to structure and the contents of the complete set of the documents proving nuclear and radiation safety of nuclear installation, point of storage, a radiation source and/or the declared activity (for nuclear power plants). RD-04-27-2000» (Appendix №4, item 16).

7.3. The contents of the documents proving nuclear and radiation safety, should correspond to requirements of the regulatory documents valid at the moment of submission of the application on reception of the license and included in «The list of the basic legal acts and the regulatory documents used by GOSATOMNADZOR of Russia at State regulation of safety in the field of atomic energy use (P-01-01-2003)».

8. Requirements to structure and the contents of the complete set of the documents proving activity on designing and manufacturing of the equipment for objects of the atomic energy use

8.1. GOSATOMNADZOR of Russia has developed the document – «Requirements to structure and the contents of the complete set of the documents proving activity on designing and manufacturing of the equipment for objects of atomic energy use. RD-03-41-2002». (Appendix №4, items 14).

The document is developed according to Regulations about licensing of activity in the field of atomic energy use.

8.2. Requirements are distributed to the complete set of the documents proving activity on designing and manufacturing of the equipment of 1, 2 and 3 safety classes for objects of the atomic energy use represented in GOSATOMNADZOR of Russia according to the sub-item "zh" of item11 of Regulations about licensing of activity in the field of atomic energy use.

8.3. Requirements are not distributed to the complete set of the documents proving activity on designing and manufacturing of fuel elements, fuel assemblies and transport-packing containers for storage and transportation of nuclear materials.

9. Requirements on preparation and decision-making on the changes of the design, technological and operational documentation influencing nuclear and radiation safety

9.1 Presentation and consideration of the documents

GOSATOMNADZOR of Russia has established requirements to the complete set of documents on the changes of the design, technological and operational documentation influencing nuclear and radiation safety and leading to updating conditions of action of the license at construction and commissioning, operation and decommissioning for objects of the atomic energy use.

9.1.1. The complete set of documents should contain:

- the application of the owner of the permission/license (the Utility);
- the materials containing the description on the reasons of change, the description of suggested changes, the analysis and substantiation of safety;
- the project of the notice on change of the design, technological and operational documentation, prepared in due order, with the documentation necessary for its consideration which is a subject to change;
- offered changes of conditions of action of permissions/ licenses;
- the conclusion of the owner of the permission/license(the Utility) on influence of changes of the design, technological and operational documentation on nuclear and radiation safety.

9.1.2. The owner of the permission/license (the Utility) addresses the complete set of documents on the changes of the design, technological and operational documentation leading, to updating of conditions of action of permissions/licenses, to the body of GOSATOMNADZOR of Russia which has given the permission/license which conditions action modification is supposed.

9.1.3. Consideration of documents is carried out by bodies of GOSATOMNADZOR of Russia by (inspection representative on object of the atomic energy use, management of district, managements of the central body of GOSATOMNADZOR of Russia) and focused on conformity to requirements of rules and norms on the nuclear and radiation safety, regulatory documents of GOSATOMNADZOR of Russia, conditions of action of the permissions / license.

9.1.4. The structure of documents on the changes of the design, technological and operational documentation influencing safety, but not leading to updating conditions of action of permissions/licenses, is defined by corresponding regulatory documents of GOSATOMNADZOR of Russia.

9.1.5. The changes leading to updating conditions of action of permissions/licenses, should be accompanied by updating (extending) the documents proving safety on the basis of which the permission/license has been given.

9.1.6. The documentation updating caused by necessity of entering changes into it should precede a realization of these changes on object of the atomic energy use.

9.2. Acceptance of the decision on change of the license action conditions.

9.2.1. If the permission/license has been given in the central body of GOSATOMNADZOR of Russia, the same body prepares the Decision on change of conditions of licenses action, taking into account the conclusions of site inspection and management of district.

9.2.2. If the permission/license has been given by management of district of GOSATOMNADZOR of Russia the given management of district prepares the Decision on change of license action conditions according to established by GOSATOMNADZOR of Russia procedures.

9.2.3. Updating conditions of action of the permission/license is carried out by GOSATOMNADZOR of Russia in time not later than 20 days after signing the corresponding Decision if other is not stipulated in the text of the Decision.

9.2.4. Procedure of consideration of changes of the design, technological and operational documentation influencing nuclear and radiation safety, but not leading to changes license conditions action is established by corresponding regulatory documents of GOSATOMNADZOR of Russia.

9.2.5. Acceptance of the final decision on, whether the planned change has influence on nuclear and radiation safety or not is a prerogative of GOSATOMNADZOR of Russia.

9.2.6. In case of reconstruction of object of the atomic energy use the question on stage-by-stage updating license conditions action can be considered by GOSATOMNADZOR of Russia if on the specified reconstruction a separate permission/license reception is not required.

9.2.7. Changes of the design, technological and operational documentation, influencing nuclear and radiation safety, but not requiring any updating of conditions of permissions/licenses action, the owner of the permission/license directs to the regional district of GOSATOMNADZOR of Russia which is carrying out supervision of activity of object of atomic energy use.

10. Certification

10.1. According to Article 37 of the Federal law «About an atomic energy use» the equipment, products and technologies for nuclear installations, radiation sources or points of storage are subjects to obligatory certification according to the legislation of the Russian Federation.

10.2. The list of the equipment, products and technologies for nuclear installations, radiation sources and points of storage, which are subjects of obligatory certification is specified in Appendix №4.

10.3. According to Article 7 of the Federal law «About industrial safety of dangerous industrial objects» the technical means, including ones made in the foreign countries, which are used on dangerous industrial object, are subjects to certification on conformity to requirements of industrial safety in established by the legislation of the Russian Federation the order. The list of the means used on dangerous industrial objects, and subjects of certification, is developed and affirms in the order determined by the Government of the Russian Federation.

10.4. In the field of fire safety the list of production and the services which are subjects to obligatory certification, is defined by the State fire-prevention service (Article 33 of the Federal law «About fire safety»).

The certificate of fire safety is an obligatory component of the certificate of conformity.

10.5. Bodies of the State control (supervision) have the right to demand from the manufacturer (the seller, the person who are carrying out functions of the foreign manufacturer) a presentation of the conformity declaration or the conformity certificate and also to suspend or stop actions of the declaration on conformity or the certificate of conformity.

10.6. Articles 29 and 30 of the Federal law "About technical regulation" determine general conditions of import into territory of the Russian Federation of production, which is a subject to obligatory confirmation of conformity.

10.7. Conditions of delivery of the import equipment, products and completing for nuclear installations, radiation sources and points of storage of the Russian Federation are determined in regulatory documents of GOSATOMNADZOR of Russia (Appendix №4, reference 17) and separately considered in Section 11 below.

11. Conditions of delivery of the import equipment for objects of the atomic energy use

11.1 For definition of conditions of delivery and application on objects of the atomic energy use of the import equipment influencing safety, GOSATOMNADZOR of Russia has developed the document named «Conditions of delivery of the import equipment, products and completing for nuclear installations, radiation sources and points of storage of the Russian Federation, RD-03-36-2002 ».

11.2. Obligatory conditions of application of the import equipment, products, materials and completing (further – just equipment) are the following:

- Compliance with the legislation of the Russian Federation in the field of the atomic energy use;
- Compliance with requirements of norms, rules and other regulatory documents of the Russian Federation in the field of the atomic energy use;
- Compliance with requirements of the obligatory certification established by *System of certification of the equipment, products and technologies for nuclear installations, radiation sources and points of storage;*
- **Positive experience of application of the import equipment, products, materials and completing parts (or their similar samples) on objects of the atomic energy use in foreign countries;**
- Absence of negative influence on the system parameters (defined in the project documentation) in which import equipment is supposed to be used;
- Opportunity for the Customer and GOSATOMNADZOR of Russia to carry out the checks and estimations of quality of the equipment during it manufacturing and/or after manufacturing, and also in other testing.

11.3. The Customer of the equipment at intention to use the import equipment on objects of atomic energy use should preliminary estimate an opportunity of delivery of the import equipment, making out the corresponding Decision.

The Decision is coordinated with the design organization and is directed to GOSATOMNADZOR of Russia.

The set of the documents directed to GOSATOMNADZOR of Russia, includes the documents which passed the examination (expertise) according to RD-03-13-99 (Appendix №4, item 12):

- Substantiation of an application possibility for the import equipment;
- Technical requirements to the equipment;
- Estimation of influence of the used import equipment on safety of nuclear installations, radiation sources and points of storage;
- Results of checks of conditions of equipment manufacture at the Supplier site (if those were carried out).

11.4. GOSATOMNADZOR of Russia approves technical requirements in case of the consent. At absence of revealed weaknesses GOSATOMNADZOR of Russia also approves the Decision on application of the import equipment.

11.5. The delivered import equipment is divided on two groups depending on their purpose and design features. A structure of groups to which conditions of delivery are distributed is shown in Appendix №6.

11.6. During manufacturing the import equipment of the first group the control over the following forms is carried out by the Customer with participation of representatives of GOSATOMNADZOR of Russia:

- Check of conditions of manufacture at the Supplier site;
- Estimation of conformity of the equipment to requirements of norms, rules in the field of atomic energy use;
- Participation in carrying out of factory acceptance tests at the Supplier site and in acceptance tests at of the Customer site according to the programs developed by the Customer and approved by GOSATOMNADZOR of Russia;

11.7. Necessity of carrying out of examination of documents for manufacturing and applications of the import equipment, concerning to the second group, is established by GOSATOMNADZOR of Russia.

GOSATOMNADZOR of Russia establishes necessity of participation of its representatives in acceptance tests of the particular equipment of the second group.

11.8. In the document RD-03-36-2002 there are also the requirements to the set of the documents represented by the Customer for the decision of a question on application of the import equipment, concerning to the first group.

11.9. Requirements of the RD-03-36-2002 document are not valid for:

- Radioisotope production, which importing is under control of the Regulations about the order of export from the Russian Federation and import into the Russian Federation the radioactive substances (and products on their basis). It is authorized by the Decision № 291 of the Government of the Russian Federation dated by March, 16, 1996;
- The transport containers delivered to the Russian Federation with the purpose of their use for nuclear materials export or import (returnable containers);
- The equipment, products and materials which are included in the list of nuclear materials, equipment of special non-nuclear materials and the corresponding technologies getting under the export control (it is authorized by the Decree №202 of the President of the Russian Federation from 14.02.1996).

Appendix №1

List of kinds of activity in the field of the atomic energy use, the license for which realization is given out by GOSATOMNADZOR of Russia

(Decision of the Government of the Russian Federation from July, 14, 1997 №865)

1. Site selection, construction, operation and decommissioning of nuclear installations, radiation sources and points of storage of nuclear materials and radioactive substances, storages of radioactive waste products.
2. The manipulation with nuclear materials and radioactive substances, including processes at investigation and extraction of uranium ores, during manufacture, use, processing, transportation and storage of nuclear materials and radioactive substances.
3. The manipulation with radioactive waste products at their storage, processing, transportation and putting them in storage.
4. Use of nuclear materials and/or radioactive substances at carrying out of research and development works.
5. Designing nuclear installations, radiation sources, points of storage of nuclear materials and radioactive substances, storages of radioactive waste products.
6. Designing and manufacturing the equipment for nuclear installations, radiation sources, points of storage of nuclear materials and radioactive substances, storages of radioactive waste products.
7. Conducting an examination of the design and technological documentation as well as the documents proving nuclear and radiation safety of nuclear installations, radiation sources, points of storage of nuclear materials and radioactive substances, storages of radioactive waste products, activity under the manipulation with nuclear materials, radioactive substances and radioactive waste products.

Appendix №2:

List of licenses for kinds of activity in the field of atomic energy use, given out by GOSATOMNADZOR of Russia (reduced)

TYPE OF THE OBJECT	OBJECTS OF APPLICATIONS OF LICENSED ACTIVITY (selection from 32 objects)	LICENSED KINDS OF ACTIVITY (REDUCED: Nuclear Installations decommissioning and manipulations with radioactive substances and waste products)								
		Object site selection (Object siting)	**Object construction**	**Object operation**	**Use of nuclear materials at carrying out research and design**	**Use of radioactive substances at carrying out research and design**	**Making projects and designing of object of atomic energy use**	**Detailed design of the equipment for object of atomic energy use**	**Production of equipment for object of atomic energy use**	**Carrying out the examinations of the documents proving safety by the expert organizations**
Nuclear Installation (NI)	Nuclear power plants and NPP Units	The license for siting of the nuclear power station	The license for a construction of the nuclear Unit	The license for operation of the block of nuclear station	The license for use of nuclear materials at carrying out research and design	The license for use of radioactive substances at carrying out research and design	The license for designing the NPP	The license for detailed designing of the equipment for the NPP	The license for manufacture of the equipment for the NPP	The license for carrying out of examination of the documents proving the NPP safety
NI	Vessels and others ships with nuclear reactors (NI)	-	The license for a construction of a vessel or other ship with NI	The license for operation of a vessel or other ship with NI	The license for use of nuclear materials at carrying out Research and design	The license for use of radioactive substances at carrying out Research and design	The license for designing a vessel or other ship with NI	The license for detailed designing of the equipment for a vessel or other ship NI	The license for manufacture of the equipment for a vessel or other ship with NI	The license for carrying out of examination of the documents proving a safety of a vessel or others ship with NI
NI	Space and flying objects with nuclear reactors (NI)	-	The same as for the NI on ship	The same as for the NI on ship	The same as for the NI on ship	The same as for the NI on ship	The same as for the NI on ship	The same as for the NI on ship	The same as for the NI on ship	The same as for the NI on ship

Appendix №3:
Differentiation of powers of GOSATOMNADZOR of Russia and its regional bodies on licensing for kinds of activity

(Appendix to the order of GOSATOMNADZOR of Russia from November, 11, 1997 №83)

The used abbreviation:

NI -Nuclear Installation

Category of object	Object	Activity, subject to licensing	The competence of the central body of GOSATOMNADZOR of Russia	The competence of inter-regional bodies GOSATOMNADZOR of Russia
NI	Nuclear power plants (Units of the nuclear power plants)	Siting, construction, operation, conclusion from operation of object The manipulation with nuclear materials, radioactive substances, radioactive waste products Use of nuclear materials, radioactive substances at carrying out research and design Designing the object Carrying out by the expert organizations of examinations of the documents proving safety	Licensing for kinds of activity	-
		Designing of the equipment for the object Manufacturing of the equipment for the object	-	Licensing for kinds of activity

Appendix №4:
List of the basic Federal laws of the Russian Federation and regulatory documents on licensing procedures in the field of the atomic energy use

1. The Federal law “About an atomic energy use» № 170-FZ from November, 21, 1995, with changes and the additions brought by Federal laws № 28-FZ from 10.02.1997, № 94-FZ from 10.07.2001, № 196-FZ from 30.12.2001, № 33-FZ from 28.03.2002.
2. The Federal law «About radiation safety of the population», № 3-FZ from 01.01.1996.
3. The Federal law «About technical regulation», № 184-FZ from 27.12.2002.
4. The Federal law «About industrial safety of dangerous industrial objects» №116-FZ from 21.07.1997, with changes and additions from 07.08.2000.
5. The Federal law «About ecological examination», № 174-FZ from 23.11.1995, with changes from 15.04.1998.
6. The Federal law of the Russian Federation «About fire safety», № 69-FZ from 21.12.1994.
7. The code of the Russian Federation «About administrative offences» from December, 30, 2001 № 195-FZ (Article 9.6.).
8. Regulations about licensing of activity in the field of the atomic energy use, with changes from 03.10.2002 (the Decision of the Government of the Russian Federation from 14.07.1997 № 865).
9. Regulations about development and the statement of Federal norms and rules in the field of atomic energy use, with changes from January, 18, 2002 (Decision of the Government of the Russian Federation from 01.12.97 № 1511).
10. Regulations about Federal supervision in Russia on nuclear and radiation safety
11. (Decision of the Government of the Russian Federation from 22.04.2002 № 265).
12. The declaration of a policy «Licenses for activity on manufacture and use of nuclear materials, an atomic energy, radioactive substances and products on their basis», accepted by board of GOSATOMNADZOR of Russia on June, 11, 1992.
13. Regulations about the order of carrying out of examination of the documents proving nuclear and radiation safety of nuclear installation, a radiation source, point of storage and/or quality of the declared activity. RD-03-13-99.
14. Requirements to structure and the contents of the documents confirming ability of the organization to carry out examination of documents on a substantiation of safety at atomic energy use and/or quality of declared activity. RD-03-39-98.
15. Requirements to structure and the contents of the complete set of the documents proving activity on designing and manufacturing of the equipment for objects of atomic energy use. RD-03-41-2002.
16. Substantive provisions of preparation, consideration and decision-making on the changes of the design, design, technological and operational documentation influencing maintenance of nuclear and radiation safety. RD-03-19-94.
17. Requirements to structure and the contents of the complete set of the documents proving nuclear and radiation safety of nuclear installation, point of storage, a radiation source and/or the declared activity (for nuclear power plants). RD-04-27-2000.

18. Conditions of delivery of the import equipment, products and completing parts for nuclear installations, radiation sources and points of storage of the Russian Federation. RD-03-36-2002.

19. The nomenclature of the equipment, products and technologies for nuclear installations, radiation sources and points of storage, subjects of obligatory certification in system of certification of the equipment, products and technologies for nuclear installations, radiation sources and points of storage (the Joint order of Ministry of Atomic Energy of Russia № 223, GOSATOMNADZOR of Russia № 28 and Gosstandart of Russia № 152 from 24.04.2000).

20. The list of the basic normative legal acts and the normative documents used by GOSATOMNADZOR of Russia for state regulation of safety in the field of atomic energy use (P-01-01-2003).

Appendix №5:
List of the equipment for objects of the atomic energy use, which designing and manufacturing requires a presentation of the complete set of proving documents

№	The name of the equipment
1.	NUCLEAR REACTOR EQUIPMENT
1.1.	**Nuclear reactors, their components and the equipment of nuclear reactors, elements of reactor cores, executive members of regulation and protection, in-core devices and components, irradiation devices with samples - witnesses, samples – mock-ups of the reactor vessel metal**
1.2.	**The vessels working under pressure**
1.3.	**The equipment of the reactor pit**
1.4.	**The equipment of heat exchangers**
1.5.	**Pumps and their units**
1.6.	**Armature (fittings)**
1.7.	**Pipelines and elements of pipelines**
1.8.	**The equipment for pneumatic and hydraulic systems**
1.9.	**The electro-technical and electronic equipment**
1.9.1.	• electronic components of I&C systems
1.9.2.	• electric equipment of networks of electric power supply
1.9.3.	• electric equipment of control systems, measurement and protection systems, devices and elements of switching for control circuits, insulators and bus bars
1.9.4.	• cables and wires
1.9.5.	• electric and electromagnetic drives of pumps and armature
1.9.6.	• electric motors of synchronous and asynchronous types, electric equipments for drives
1.9.7.	• gauges, signaling devices
1.9.8.	• converters of frequency
1.9.9.	• units of a uninterrupted power supply, batteries, stand-by power supplies, switchyards, low-voltage switchyards
1.9.10.	• circuit breakers, short circuit devises, separators, breakers of power supplies

1.9.11.	• transformers, stabilizers
1.9.12.	• fuses, patrons and holders to them, switches, electromechanical contactors and actuators
1.9.13.	• converters of the electric power of an alternating current into DC
1.9.14.	• heating elements
1.9.15.	• diesel generators, electric generators, turbine generators
1.9.16.	• transformer substations of in-house supply
1.9.17.	• panel-board devices (cabinets, boards, panels)
1.10.	**Instrumentations and control systems**
1.10.1.	• the equipment of control systems, regulations, protection, automation, diagnostics, I&C systems
1.10.2.	• the equipment of in-core monitoring systems
1.10.3.	• the equipment for detecting neutrons and neutron flux inside reactor core
1.10.4.	• the equipment of the fuel elements condition monitoring
1.10.5.	• means of computer systems
1.10.6.	• computerized control systems
1.11.	**The equipment of isolation safety systems**
1.12.	**Elements of radiation, biological protection and thermal isolation**
1.13.	**Mechanical operational components and systems (special load-lifting cranes)**
1.14.	**Basic and carrying metalwork**
1.15.	**Gas blowers, compressors, turbines**
1.16.	**Transport-technological means for the manipulation with nuclear fuel, radioactive substances and radioactive waste products**
2.	MEANS OF PHYSICAL PROTECTION SYSTEMS
2.1.	**The equipment of the security systems, auxiliary devices**
2.2.	**The equipment of control and access, auxiliary devices**
2.3.	**The equipment of information gathering, displaying and processing systems**
2.4.	**Means of detection and monitoring**
2.5.	**Means of detection of a transportation of nuclear materials, explosives and subjects made from metal**

2.6.	**The equipment of communication lines**
2.7.	**Security devices and signalization systems**
3.	NUCLEAR AND RADIOISOTOPE DEVICES
3.1.	**Devices, installations, dosimetric systems**
3.2.	**Devices, installations, radiometric systems**
3.3.	**Devices, installations, spectrometers**
3.4.	**Monitors of radiation nuclear materials**
3.5.	**Devices and the equipment of systems of the account and the control of nuclear materials**

Appendix №6:
Provisional structure of groups of the equipment and the products influencing safety of nuclear and radiation objects to which conditions of delivery are defined

THE FIRST GROUP

1. Heat exchanging equipment and products.
2. The vessels working under pressure.
3. The electro-technical equipment and products.
4. The power electro-technical equipment of a low, average and high voltage.
5. Pumps and components.
6. Armature (fittings) and its components.
7. Pipelines of systems, important for safety.
8. Refueling machines and their components.
9. Permanently established load-lifting cranes used in a work cycle of nuclear installations, radiation sources and points of storage.
10. The equipment and products for processing and storages of radioactive waste products.
11. Transport containers for nuclear materials and radioactive substances.
12. The basic and welding materials for the equipment of the first group.
13. Radiation non-destructive testers, radiation therapeutic devices.

THE SECOND GROUP

1. Instrumentations.
2. Gauges and detectors for the control and measurements of thermal hydraulic, physical-chemical and nuclear- physical parameters.
3. The dosimetric equipment, devices and products.
4. The equipment of physical protection systems.
5. Electric and radio products.
6. Cable products.
7. Software.
8. Software based technical complexes.
9. The equipment and products of systems of the operational control and diagnostics of nuclear installations.

부록 II

한-러 계측제어 규제요건 검토:
안전계통설계기준

Comparison of the Standards
applied to NPP I&C design in Korea and Russia

Comparison of the IEEE Std 603-1998
"IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations" (applied in Korea)
and
Analogues (similar) standards applied in Russia

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Dr. Semen Malkin

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1. Introduction

The main objective of hereby comparison is to compare safety criteria and requirements, stipulated in the IEEE Std 603-1998 and applied in many developed countries including Republic of Korea, with the Russian analogues standards.

The mentioned above standard is well-structured and balanced document of high level, which describes the main criteria and general functional and design requirements to the I&C portion of the safety systems of all types. Unfortunately, the conducted research has shown that there is no close analogue to IEEE Std 603-1998 among the Russian standards, there is no such standard, which is fully focused on the same topic (has the same scope) and developed based on similar systematic approach.

However, there are several Russian standards (partially overlapping), which cover the main aspects of the same topic as IEEE Std 603, see the documents listed in the Table 1. They have been selected for comparison and considered in the frame of hereby work. The results of the comparison are presented in Sections 3 and 4, justification (the main reason) of the Russian standards selection is briefly described below.

Table 1. List of the standards selected for comparison.

IEEE Standard applied in Korea	Standards applied in Russia, selected for a comparison
IEEE Std 603-1998 "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations"	1. OPB-88/97 (PNAE G-01-011-97) General statements of providing nuclear power plants safety, Moscow 1997. 2. PBYa RU AS-89 (PNAE G-1-024-90) Nuclear safety rules for reactors of nuclear power plants, Moscow 1990. 3. NP-026-01 Requirements to control systems important to safety in nuclear power plants, Moscow 2001. *Additional standard used for clarification of limited number of definitions and requirements:* 4. GOST 26843-86 Nuclear power reactors. General requirements for control and protection system, Moscow 1986 (new edition in 1989). 5. *GOST R ISO 9000-2001 "Quality management systems. Fundamentals and vocabulary"*

Standard 1 is selected for comparison because this standard defines the main criteria and general rules for safe design and operation of nuclear power plants. It covers the main safety terms, safety classification of the NPP systems and equipment and general requirements to the systems and equipment design, commissioning, operation, personnel training, emergency planning and decommissioning.

Standard 2 is selected because this standard defines the main qualitative and quantitative requirements for nuclear power reactor core, reactor safety and safety related systems. The standard does not concern the safety systems of all type (focused mostly on reactor scram system and partially on emergency core cooling system).

Standard 3 provides some additional general requirements to the control systems important to safety and introduces functional groups of controlling safety systems.

Standard 4 provides requirements to the NPP reactor control and protection system only (Russian SUZ system). It was issued right before the Chernobyl accident and originally based on old version of the Standard 2. Then it was updated after issue of the new version of the Standard 2. In many respects it repeats Standard 2, but also gives some new requirements (for example, quantitative requirements for SUZ reliability).

Standard 5 fully corresponds (is authentic) to ISO 9000-2000 that is why it contains terms and definitions, which are much closer to the IEEE Std 603 than original Russian standards, see for example Section 5.4 in Table 5.

2. Acronyms

The following acronyms are used in IEEE Std 603-1998 and this report:

GOST	Russian abbreviation (State Standard)
IEEE	Institute of Electrical and Electronics Engineers
NPP	Nuclear Power Plant
SFC	Single-Failure Criterion
SUZ	Russian abbreviation of nuclear reactor control and protection system, which fulfils reactor power control and scram function
QA	Quality Assurance

3. Comparison of the standards

Tables 2-8 below present the results of step by step comparison of the standards in order of the IEEE Std 603 table of contents. Introduction and explanatory (informative) annexes are not included.

3.1 Scope and references

Table 2. Comparison of the scope and references

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
1.	**SCOPE** Minimum functional and design requirements for the power, instrumentation and control portions of safety systems for NPPs	Standard 1: Sections 1, 2, 4 and partially 5 Standard 2: Sections 1, 2 and 3 Standard 3: The entire document Standard 4: The entire document Standard 5: Only some terms
1.1	**Illustration** Clear illustration is given to assess the scope of the standard	No similar illustration is found in Russian analogues
1.2	**Application**	The same as 1.1
2.	**REFERENCES** The full list of all relevant standards is given. For example, references to specific standards on the setpoints and power sources	Standard 1: No references at all Standard 2: One reference to Standard 1 Standard 3: One reference to Standard 1 Standard 4: A few references only Standard 5: Comprehensive list of references

3.2 Definitions

Table 3. Comparison of definitions and terms

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
3.	**DEFINITIONS**	
3.1	**acceptable**	No such definition in selected standards but it sense is clear even without definition.
3.2	**actuated equipment**	Standard 2 (terms 10) gives similar definition for reactor control and trip system, but this term combines actuated equipment with the execute features, see also

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
		Section 3.15.
3.3	**actuation device**	No such definition in selected standards.
3.4	**administrative controls**	Standard 1 (term 2) Standard 2 (term 3) give similar definition but it related only to people fulfilling an administrative control (not to control functions).
3.5	**analytical limit**	Standard 1 (term 43) Standard 1 (term 26) give similar but less exact definition of “safety operation limit”.
3.6	**associated circuits**	No such definition in selected standards.
3.7	**auxiliary supporting features**	Standard 1 (term 34) defines these systems as “supporting safety systems”.
3.8	**channel**	Standard 1 (term 21) and Standard 2 (item 13) give similar but more generic definition of system channel (not limited by protection system).
3.9	**Class 1E**: The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling and containment & reactor heat removal…	**No direct analogues in the Russian standards.** Standard 1 (Section 2) introduces 4 safety classes for NPP systems and elements. Class 1E corresponds to the I&C part of Class 2 safety systems (there are also some systems and elements of normal operation (not safety systems), which are classified by safety Class 2. Russian safety Class 1 denotes fuel and core elements which can cause the behind design accidents.
3.10	**common-cause failure**	Standard 1 (term 36) gives similar and even more detailed definition.
3.11	**components**	Standard 1 (term 72) gives similar definition of “elements” but it refers to reliability and safety analysis
3.12	**design basis events**	Standard 1 (term 47) and Standard 2 (term 33) give similar definition.
3.13	**detectable failures**	Standard1 (term 31) give a definition of **undetectable** failure which has the inverse sense.
3.14	**division**	No such definition in selected standards.
3.15	**execute features**	Standard 2 (terms 10 and 35) gives similar definition for reactor control and trip system, but term 10 combines execute features with actuated equipment, see also Section 3.2.
3.16	**maintenance bypass**	No such definition in selected standards.

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
3.17	**module**	No such definition in selected standards but it sense is clear without definition.
3.18	**operating bypass**	No such definition, Standard 3 (term 3) gives more general definition of interlock (not relevant to safety function like operating bypass).
3.19	**power sources**	No such definition in selected standards but it sense is clear without definition.
3.20	**protection system:** The part of the sense and command features involved in generating those signals used primarily for reactor trip system and engineered safety features	**All Russian standards defines a protection system differently** as compared with IEEE-603: Standard 1 (term 19) defines a protection safety system as a system intended for fuel and primary circuit protection (not only sense and command features but entire system). Standard 2 (term 1) defines a protection system (emergency protection) as a safety system meant for reactor trip (entire reactor scram system). Standard 3 defines a protection as a control function aimed to prevent equipment damages, use of failed equipment and improper personnel actions.
3.21	**protective action:** Initiation of a signal…for the purpose of accomplishing a safety function.	Standard 2 (term 39) introduces similar term “signal of emergency protection”, which however regards to reactor trip function only.
3.22	**redundant equipment or system**	Standard 2 (term 32) gives similar definition to “principle of redundancy”.
3.23	**safety function**	Standard 1 (term71) and Standard 2 (term 57) gives similar but less exact definition (safety functions are not listed).
3.24	**safety group**	No direct analogues in the main Standards 1 and 2. Standard 3 introduces “functional group”, which has similar sense.
3.25	**safety system**	Standard 1 (term 57) and Standard 2 (item 42) give similar definitions but according to them safety systems are not limited to design basis events.
3.26	**sense and command features**	**Generally there is no exactly such term in Russian standards, which is valid for all safety systems.** Standard 1 (term 64) gives similar definition named “controlling safety system”, but it is not valid for reactor scram system. Standard 2 (term 14) gives similar definition named “set of devices for emergency protection” but it is used for reactor scram system only.

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
3.27	**sensor**	No such definition in selected standards but it is clear even without definition.

For more information regarding the terms differences see also Section 5.4 in Table 5.

3.3 Safety system design basis

Table 4. Comparison of the safety system design basis

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
4.	**SAFETY SYSTEM DESIGN BASIS** This Section states that the specific basis shall be established for the design of each safety system and lists a minimum contents of its documentation	In general the Russian Standards contain the same or similar statements regarding safety system design basis. However, there are some differences because Section 4 gives a minimum list of requirements and the scope of the standards is different. The main differences are that Standard 1: • Requires and describes implementation the defense-in-depth philosophy as the main basis for NPP safety and explains it at 5 levels including personnel training and safety culture (Section 1.2.3). • Excludes from the design basis events a rupture of some vessels provided it is shown that probability of reactor vessel rupture is not higher than 10^{-7} for reactor per year (Section 1.2.16). • Requires physical protection and providing fire safety (Section 1.2.22). At the same time the Russian standards do not contain some important requirements listed in IEEE Std 603 Section 4 or give them in other way, namely: c) They do not have requirements for the permissive conditions of operating bypass capability, even such term as “operating bypass” is not used, see Table 3. e) They require blocking of operators manual actions for 10-30 min (Standard 1 Section 4.4.5.3 and Standard 3 Section 4.6) after a safety system actuation. For this case the IEEE Std 603 requires only defining points in time, plant’s and environmental conditions for manual operations (no exact data on block time for all cases).

3.4 Safety system criteria

Table 5. Comparison of the safety system criteria

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
5.	**SAFETY SYSTEM CRITERIA**	
5.1	**Single-failure criterion**	Standard 1 (Section 1.2.12) introduces very similar but not the same criterion. Standard 2 (Section 2.3.2.10 and 2.3.2.22) gives even more strict requirements for reactor trip system. Differences are following: • Standard 1 limits **Single-failure criterion (SFC)** by the failures of active elements and passive elements having mechanical movable parts and does not include "all failures caused by the single failure". • **Standard 2** (Sections 2.3.2.9, 2.3.2.10 and 2.3.2.21) **requires much more redundancy for reactor emergency protection system than SFC:** 2 independent sets of protection, each shall have 3 independent channels as minimum for reactor protection against neutron power and neutron power rate increase as well as **minimum voting logic 2 out of 3 for each set of protection.** *NB: One may find additional difference of Standard 1, which considers in SFC personnel failure too. However, IEEE Std 603 has explanation that the SFC applies to safety systems with automatic and manual control, what means similar approach.*
5.2	**Completion of protective action**	Standard 1 has the same requirement in Section 4.1.11.
5.3	**Quality**	Standard 1 also requires application of QA activity and program for safety and safety related system design, documentation and handling (Sections 1.2.6 and 1.2.7).
5.4	**Equipment qualification**	**It is important that there is no equivalent term in the main selected Russian standards.** **Standard 1 (term 22) introduces "qualification" for personnel only**. However, the requirements similar to "Equipment qualification " are given in Section 4.1.5 of Standard 1 *NB: New Standard GOST R ISO 9000-2001 "Quality management systems. Fundamentals and vocabulary" introduces the definition very similar to the IEEE Std 603.* *However, Standard 1 still has a priority for the safety system engineering.*
5.5	**System integrity**	Standard 1 (Section 4.1.5) contains the same

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
		requirement.
5.6	**Independence**	
5.6.1	Between redundant portions of a safety system	Standard 1 (Section 4.4.5.7) requires independence for safety system but does not give any details and **does not require physical separation** for safety system redundant portions. Standard 2 (Section 2.3.2.10) requires independence of reactor trip system channels. **Only Standard 3 (Section 4.8) partially reflects this requirement.**
5.6.2	Between safety systems and effects of design basis event	Standard 1 (Section 4.1.5) has similar requirement but **does not include physical separation.**
5.6.3	Between safety systems and other systems	Standard 1 (Sections 4.1.9 and 4.4.5.6) has the same requirement. Standard 2 (Section 2.3.2.14) has the same requirement for reactor trip system. Standard 3 (Attachment 1) also gives a similar requirement.
5.6.3.1	*Interconnected equipment*	The same is required in Standard 1 (Sections 2.6 and 2.7).
5.6.3.2	*Equipment in proximity* *a. Separation* *b. Barrier*	**There is no requirement of physical separation** of the equipment and systems that are in physical proximity to safety systems but are not safety graded. Physical barriers are not introduced for this purpose.
5.6.3.3	*Effects of a single random failure*	Similar (but not the same) requirement can be found in Sections 4.1.6, 4.4.5.6 and 4.4.5.7 of Standard 1.
5.6.4	Detailed criteria	No such detailed criteria in Russian standards.
5.7	**Capability for testing and calibration**	Standard 1 (Sections 4.1.10 and 4.4.5.8) and Standard 2 (Section 2.3.2.17) give similar but a little bit less strict requirement. **Testing during power operation is not directly required (IEEE Std 603 requires but with some exceptions),** definition of time and period of testing are left for NPP design documentation. The term "calibration" is not used in the main Standards. Instead of "calibration" a similar term "metrological attestation" is applied in Standard 2 (Section 2.3.2.18). Standard 3 (Section 2.4) contains similar requirement regarding "calibration" of safety systems.

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
5.8	Information displays	
5.8.1	Displays for manually controlled actions	Standard 1 (Sections 4.4.2.3 and 4.4.2.4), Standard 2 (Section 2.4.4) and Standard 3 (Section 2.6) have similar requirements, **however there is no such important requirement as "The design shall minimize the possibility of ambiguous indications that could be confusing to the operator".**
5.8.2	System status indication	See Section 5.8.1.
5.8.3	Indication of bypasses	The main Standards 1 and 2 do not contain such important requirement. Only Standard 3 (Section 3.11) introduces the same requirement.
5.8.4	Location: Information displays shall be located accessible to the operator…visible from the location of the manual control	**No such useful requirement.** One may consider this requirement as quite trivial but it is not the case. Standard 1 (Section 4.4.2.3) requires optimization of human-machine interface, but it is not enough because difficult to check.
5.9	**Control of access**	The same and similar requirements can be found in Standard 1 (Sections 1.2.22, 5.1.5), Standard 2 (Sections 2.3.2.25 and 2.6.6) as well as in Standard 3 (Section 4.9).
5.10	**Repair**	Similar requirements are in Standard 1 (Sections 4.1.4, 4.1.10, 4.4.4.3 and 4.4.5.8) in Standard 2 (Section 2.3.2.17).
5.11	**Identification**	**Russian Standards do not have the requirement c):** **"Identification of safety system equipment shall be distinguishable from any identifying markings placed on equipment for other purposes".**
5.12	**Auxiliary features**	The same in Russian Standards, the requirements for auxiliary (supporting) safety systems are included in the Standard 1 (Section 4.7).
5.13	**Multi-unit stations**	This topic is not covered in the selected Standards.
5.14	**Human factors considerations**	Standard 1 (Section 4.4.2.3) has similar requirement, **however there is no such important detail as "during initial stage** and throughout the design process".
5.15	**Reliability**	Russian Standards give more detailed and strict requirements:

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
		Standard 1 (Sections 1.2.16, 1.2.17 and 1.2.19) and Standard 2 (Section 2.1.13) require probability safety assessment with prescribed allowed probabilities of the possible accidents. Standard 2 (Section 2.3.1.2) requires quantitative assessment of reliability for reactor control and protection system (SUZ) and Standard 4 introduces quantitative requirements to SUZ reliability: unavailability of scram function - not more than 10^{-5}, mean time before failures of control system – not less than 10^{5} hours, mean repair time – not more than 1 hour.
5.16	**Common cause failure criteria**	Standard 1 (Section 4.1.6) has the same requirement.

3.5 Functional and design requirements to sense and command features

Table 6. Comparison of the functional and design requirements to sense and command features

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
6.	**SENSE AND COMMAND FEATURES - FUNCTIONAL AND DESIGN REQUIREMENTS**	
6.1	**Automatic control**	Standard 1 (Section 4.4.5.3) contains similar and even more detailed requirement (operator manual trip of safety system after it automatic start-up shall be blocked during 10-30 min).
6.2	**Manual control**	Standard 1 (Sections 4.1.11 and 4.4.5.4), Standard 2 (Section 2.3.2.23) and Standard 3 (Section 4.3) contain similar requirements.
6.3	**Interaction between the sense and command features and other systems**	
6.3.1	Requirements	No such requirements.
6.3.2	Provisions	No such requirements.

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
6.4	**Derivation of system inputs**	**No such requirements (for safety systems a derivation of the signals, which are direct measures of the desired variables, is not required).**
6.5	**Capability for testing and calibration**	
6.5.1	Checking the operational availability	Standard 1 (Sections 4.1.10 and 4.4.5.8), Standard 2 (Section 2.3.2.17) and Standard 3 (Section 2.4) contain similar requirements.
6.5.2	Assuring the operational availability	In several places there are the statements with similar ideas but they are formulated as a separate requirement.
6.6	**Operating bypasses**	**No such requirement and even such term,** see Table 3.
6.7	**Maintenance bypass**	Even without using such term, see Table 3, the same requirement is reflected in Standard 1 (Section 5.1.5, Standard 2 (Section 2.3.2.20) and Standard 3 (Section 3.11).
6.8	**Setpoints**	No term and definition of analytical setpoint and no requirement that allowance for uncertainties between the process analytical limit and the devise setpoint shall be determined using a documented methodology.

3.6 Functional and design requirements to execute features

Table 7. Comparison of the functional and design requirements to execute features

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
7.	**EXECUTE FEATURES (FUNCTIONAL AND DESIGN REQUIREMENTS)**	
7.1	**Automatic control**	No such requirement but it is quite trivial.
7.2	**Manual control**	No such requirement.
7.3	**Completion of protective action**	Standard 1 has the same requirement in Section 4.1.11.
7.4	**Operating bypass**	Neither such term nor such requirement.
7.5	**Maintenance bypass**	No such term but functional requirements are similar.

3.7 Power sources requirements

Table 8. Comparison of the requirements to power sources

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
8.	**POWER SOURCE REQUIREMENTS**	
8.1	**Electrical power sources**	Standard 1 (Section 4.7) has similar requirements; Standard 4 has similar and even more detailed requirements for electrical power supplies of SUZ system.
8.2	**Non-electrical power sources**	Standard 1 (Section 4.7) has similar requirements.
8.3	**Maintenance bypass**	No such term but functional requirements are similar.

4. Conclusion

The IEEE Std 603 – 1998 standard is well-structured and balanced document of high level, which describes the main criteria as well as general functional and design requirements to the I&C portion of the safety systems of all types. Unfortunately, the conducted research has shown that there is no close analogue to the IEEE Std 603-1998 among the Russian standards, there is no such standard, which is fully focused on the same topic (has the same scope) and developed based on similar systematic and balanced approach.

There are several Russian standards, which cover the main aspects of the same topic, see the selected documents listed in the Table 1. However, they are less useful for the safe and qualitative design of I&C portion of safety systems, because:

- Their original versions were developed far before Chernobyl accident, when the first Russian nuclear power plants did not have a full set of needed safety systems and the designers did not follow the best international practices in NPP safety provision (the first version of Standard 2 was issued in 1974, Standard 2 - in 1982). After the accident they have been significantly modified, but today it is better to rewrite them fully (author's personal opinion).
- They have been developed by different people and are partially overlapping and even repeating each other; furthermore in some parts they are contradictory.
- In many respects they do not follow the international terminology (definition of protection system, equipment qualification, operating bypass, etc) and classification, for example safety classification the NPP systems and functional classification of the safety systems are different, see Table 3. That is why they cannot be easily harmonized with the international standards.
- They are not comprehensive enough. That is why an additional Standard 3 “Requirements to control systems important to safety in NPPs” was issued in 2001, but the research made during hereby comparison has shown that it is still not enough.

So, the first conclusion is that the IEEE Std 603 – 1998 is more comprehensive and useful for the designers of safety systems (namely their I&C portion) than the existing Russian standards.

The second question: is it strict enough? Unfortunately, there is no direct and unambiguous answer on this question.

In majority of cases, the criteria and requirements introduced by the IEEE Std 603 - 1998 are strict enough and even stricter than ones given in the Russian standards. Examples are following (see Tables 4-8):

- Common cause failure criterion;
- Completion of protective action;
- Quality;
- Capability for testing and calibration**;**
- Control of access;
- Independence (stricter for physical separation and barriers for safety system channels);
- Information displays (stricter);
- Identification of safety systems (stricter);
- Setpoints (stricter);
- Derivation of system inputs (stricter);
- Human factors considerations (stricter).

However, there are some important cases when the Russian standards are stricter, for example:

- **Single-failure criterion (namely a level of redundancy) -** Standard 2 requires much more than SFC for reactor emergency protection system: 2 independent sets of protection, each shall have 3 independent channels as minimum for reactor protection against neutron power and neutron power rate increase as well as minimum voting logic 2 out of 3 for each set of protection;
- **Reliability -** Russian standards give more detailed and strict requirements. Standard 1 and Standard 2 require probability safety assessment with prescribed allowed probabilities of the possible accidents. Standard 2 requires quantitative assessment of reliability for reactor control and protection system (SUZ) and Standard 4 introduces quantitative requirements to SUZ reliability: unavailability of scram function - not more than 10^{-5}, mean time before failures of control system – not less than 10^{5} hours, mean repair time – not more than 1 hour.

Finally, one may conclude that credit can be given to the safety systems (namely their I&C portion), which are designed in accordance with the criteria and requirements stated in the IEEE Std 603 – 1998. There are no doubts that they can be successfully certified and implemented at Russian NPPs. Nevertheless, this cannot be done automatically without special expertise of the safety systems on compliance with the requirements of the Russian standards.

부록 III

한-러 계측제어 규제요건 비교검토:

디지털컴퓨터안전계통 설계기준

Comparison of the Standards
applied to NPP I&C design in Korea and Russia

Comparison of the IEEE Std 7- 4.3.2-1993 “IEEE Standard for Digital Computers in Safety Systems of Nuclear Power Generating Stations” (applied in Korea)

and

Analogues (similar) standards applied in Russia

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1. Introduction

In the introduction to the IEEE Std 7- 4.3.2-1993 standard ("IEEE Standard for Digital Computers in Safety Systems of Nuclear Power Generating Stations") it is highlighted that the mentioned standard specifies *additional specific requirements to supplement* the criteria and requirements of the IEEE Std 603-1998 when digital computers are used in the safety systems. That is why it should be used in conjunction with IEEE Std 603-1998 to assure a completeness of the safety system design when a computer is to be used as a component of the safety system.

Taking into account the mentioned above specific of the IEEE Std 7- 4.3.2-1993 and it close relation with the IEEE Std 603-1998, it was decided to compare its requirements with the Russian analogous by following the same approach and basis as in case of the IEEE Std 603-1998 comparison.

So, the main Russian standards selected for comparison of the IEEE Std 7- 4.3.2-1993 are kept the same as in case of the IEEE Std 603-1998 comparison, with the same numbers in the list, given in Table 1.

Due to significant delay in implementation of digital computers in safety systems at Russian NPPs there are no full analogues to IEEE Std 7- 4.3.2-1993 among the Russian standards. However, the closest Russian analogue to the IEEE Std 7- 4.3.2-1993, which partially covers the same aspects but for nuclear reactor I&C only, is GOST 29075-91. It was not considered before and that is why it is added to the list in Table 1 with number "6". Such numeration provides possibility to make simple quotations from the IEEE Std 603-1998 comparison when it is needed because many requirements of the IEEE Std 7- 4.3.2-1993 just repeat the requirements of the IEEE Std 603-1998 (it means that for these items there are no additional requirements which reflect a specific aspects of the digital computers usage in safety systems).

2. Acronyms

The following acronyms are used in IEEE Std 7- 4.3.2-1993 standard and this report:

ACE Abnormal Conditions and Events
FAT Factory Acceptance Testing
FTA Fault Tree Analysis
FMEA Failure Modes and Effects Analysis
GOST Russian abbreviation (State Standard)
IEEE Institute of Electrical and Electronics Engineers
NPP Nuclear Power Plant
NQA Nuclear Quality Assurance
SDD Software Design Description
SFC Single-Failure Criterion
QA Quality Assurance
V&V Verification and Validation

Table 1. List of the standards selected for comparison.

IEEE Standard applied in Korea	Standards applied in Russia, selected for a comparison
IEEE Std 7- 4.3.2-1993 standard "IEEE Standard for Digital Computers in Safety Systems of Nuclear Power Generating Stations".	1. OPB-88/97 (PNAE G-01-011-97) General statements of providing nuclear power plants safety, Moscow 1997. 2. PBYa RU AS-89 (PNAE G-1-024-90) Nuclear safety rules for reactors of nuclear power plants, Moscow 1990. 3. NP-026-01 Requirements to control systems important to safety in nuclear power plants, Moscow 2001. *Additional standard used for clarification of limited number of definitions and requirements:* 4. GOST 26843-86 Nuclear power reactors. General requirements for control and protection system, Moscow 1986 (new edition in 1989). 5. GOST R ISO 9000-2001 "Quality management systems. Fundamentals and vocabulary". *The most close analogue among the Russian standards:* 6. GOST29075-91. Nuclear instrumentation systems for nuclear power stations. General requirements (OKP 43 6240).

The reasons of the selection of the standards 1-5 in the Table 1 are described above in the part, which compares the IEEE Std 603-1998 requirements.

The reason of the selection of the standard 6 is already mentioned above – it contains some specific requirements for hardware and software of the digital computers used in the safety system, but not only. It also covers some requirements to nuclear I&C (not only digital computers) reliability and qualification, which are beyond the scope of the IEEE Std 7- 4.3.2-1993.

3. Comparison of the standards

Tables 2-8 below present the results of step-by-step comparison of the standards in order of the IEEE Std 7- 4.3.2-1993 table of contents. Introduction and explanatory (just informative) annexes are not included.

3.1 Scope and references

Table 2. Comparison of the scope and references

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
1.	**SCOPE** Additional requirements not specifically addressed in IEEE Std 603, amplifying criteria for computers	Standards 1-4: general requirements only. Standard 5: only some terms. Standard 6: has broader scope but also amplifies. criteria for computers.
2.	**REFERENCES** The full list of all relevant standards is given, including QA standards and software V&V.	Standard 1: No references at all. Standard 2: One reference to Standard 1. Standard 3: One reference to Standard 1. Standard 4: A few references only. Standard 5: Sufficient list of references. Standard 6: Sufficient list of references.

3.2 Definitions and abbreviation

Table 3. Comparison of definitions and abbreviation

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
3.1	**DEFINITIONS**	
3.1.1	**Commercial grade item**	No such definition in selected standards but it sense is clear even without definition.
3.1.2	**Commercial grade dedication**	No such definition in selected standards and the **process of dedication is not described.**
3.1.3	**Firmware**	No such definition in selected standards but it sense is explained in Standard 6 Section 3.2.5 (software fixed in read-only memory).

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
3.1.4	**Safety system**	Standard 1 (term 57) and Standard 2 (item 42) give similar definitions but according to them safety systems are not limited to design basis events. **Definition given in Standard 6 includes functions of normal operation and covers also organizational measures (that is really nonsense!)**
3.1.5	**Software tools**	No such definition in selected standards.
3.1.6	**System testing**	Standard 1 Section 46 gives a similar definition.
3.1.7	**Verification and validation**	Only Standard 5 has this definition.
3.2	**ABBREVIATIONS**	See Section "**Acronyms"** above.

3.3 Safety system design basis

Table 4. Comparison of the safety system design basis

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
4.	**SAFETY SYSTEM DESIGN BASIS** IEEE Std 7- 4.3.2-1993 requires firstly following IEEE Std 603 requirements. Additional requirement is that the range of transient and steady state conditions shall include the electromagnetic environment, including electrostatic discharge. Annex C contains the recommendations how to protect I&C against EMI.	The same as in case with IEEE Std 603 considered above. Additional similar requirements are given in Standard 6, Sections 8.1- 8.6. Some of these requirements are even more detailed, for example: • required tolerance to external EMI – up to 5 kV/m for electrical fields and • up to 400 A/m for magnetic fields. The selected standards do not contain the recommendations for I&C protection against EMI.

3.4 Safety system criteria

Table 5. Comparison of the safety system criteria

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
5.	**SAFETY SYSTEM CRITERIA**	
5.1	**Single-failure criterion (SFC)** No requirements beyond IEEE Std 603	Almost the same as in case with IEEE Std 603 considered above. Standard 6, Section 2.9 additionally requires that nuclear I&C system design shall give a possibility to allocate redundant technical means in different compartments (to comply with SFC).
5.2	**Completion of protective action** No requirements beyond IEEE Std 603	The same as in case with IEEE Std 603 considered above.
5.3	**Quality** In addition to the requirements of IEEE Std 603, the following requirements are necessary in order to meet quality criterion, see items 5.3.1-5.3.5	In general, the requirements for quality are the same as in case with IEEE Std 603 considered above. Standard 6, Section 6.4 requires additionally: • Development of QA programs for all lifetime stages; • **Usage of the I&C components marked as acceptance "5" ("special conditions of supply").**
5.3.1	Software development	There are no such exact requirements in the selected standards. Software development is described in other standards, see comparison of the IEEE Std 1012 given below. Standard 6, Section 3.1.2 requires **programming in accordance with principles of structural programming, as a rule, based on completed modules (one module - one function).** As a rule, a text of one module shall not exceed 100 operators. Additionally Section 3.1.11 requires for the software being developed **a compliance with quality indicators** (correctness, reliability, maintainability, usability, etc.). Section 3.2.5 requires that **protection setpoints shall be realized by fixed hardware or firmware.**

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
5.3.2	Qualification of existing commercial computer	There are no such requirements and even definition of qualification is different, see comparison of the IEEE Std 603. However, Standard 6 contains some requirements to nuclear I&C as for EMI, seismic and environmental testing (Sections 5, 6 and 8). **Standard 6, Section 3.1.8 limits usage of the operating systems for safety important systems.** Section 3.1.7 gives a preference to reliable commercial software proven by experience, certified and allowed for application at NPPs. Section 5.2.3 requires that those technical means of safety classes 2 and 3, which contain micro-computers, shall keep their operability in dusty conditions and in case of presence of corrosion-active substances in air.
5.3.3	Software tools	There are no such requirements in selected standards and even such term is not defined.
5.3.4	Verification and validation	There are no such requirements in selected standards. Software development is described in other standards, see comparison of IEEE Std 1012 given below.
5.3.5	Software configuration management	There are no such requirements in selected standards and even such term is not defined.
5.4	**Equipment qualification** Additional requirement is following. EQ testing shall be performed with the computer functioning with software and diagnostics that are representative of those used in actual operation. All computer parts shall be exercised during testing.	Standard 6, Sections 2.4.2 and 4.1.3 contain similar requirements but not exactly the same. **Exact requirement** that “EQ testing shall be performed with the computer functioning with software and diagnostics that are representative of those used in actual operation. All computer parts shall be exercised during testing” **has not been found.** This is important.

5.5	**System integrity**	
5.5.1	Design for computer integrity: the computer shall be designed to perform its safety function when subjected to all conditions, external or internal, that have significant potential for defeating the safety function (e.g. input and output processing failures, electrical input voltage and frequency fluctuations, EMI, etc.).	Similar requirements can be found in Standard 6, but they are grouped under the same title (“Design for computer integrity”). Section 2.8.2 requires: • Interruption of power supply for a time not more than 20 ms shall not lead to appearance of false commands and/or messages as well as computer reset and memory loosing for the I&C systems of safety classes 1,2 and 3. • Power supply voltage fast changes in the range from –25% up to +25% of rated value shall not cause reactor trip signal generation (for systems of safety class 1). Section 3.1.9 requires to protect software against input information failures, computer faults, unauthorized access and personnel mistaken actions. Section 5 contains requirements on seismic, environmental and external mechanical affects. Sections 8.2 requires: • tolerance to external EMI – up to 5 kV/m for electrical fields and • up to 400 A/m for magnetic fields. Section 8.3 requires for systems of safety classes 1,2 and 3 operational stability and functioning without failures under pre-specified conditions of voltage and frequency fluctuations, external EMI.
5.5.2	Design for test and calibration: The test and calibration function shall not adversely affect of the ability to perform its safety function.	Standard 6, Section 3.1.4 requires self-testing for the systems of safety classes 1,2 and 3. This self-testing shall not affect fulfillment of safety functions.
5.6	**Independence** Data communication between safety or between safety and non-safety systems shall not inhibit the performance of the safety function	Similar but not such exact requirements are reflected in Standards 1-3, see comparison of the IEEE Std 603, and partially in Standard 6. Standard 6, Section 2.1 requires an identification and analysis of interconnections for each system. Section 3.1.4 requires self-testing for the systems of safety classes 1,2 and 3. This self-testing shall not affect fulfillment of safety functions.

5.7	**Capability for testing and calibration** No requirements beyond IEEE Std 603	The same as in case with IEEE Std 603 considered above.
5.8	**Information displays** No requirements beyond IEEE Std 603	The same as in case with IEEE Std 603 considered above.
5.9	**Control of access** No requirements beyond IEEE Std 603.	Standard 6, Section 2.10 requires organizational, design or technical means of protection against unauthorized access. Section 6.2 of the same Standard additionally requires from the I&C design an elimination of unauthorized access for the devises of safety classes 1,2 and 3. Section 3.1.9 requires a protection from unauthorized access to software and data. Other is the same as in case with IEEE Std 603 considered above.
5.10	**Repair** No requirements beyond IEEE Std 603.	The same as in case with IEEE Std 603 considered above.
5.11	**Identification** No requirements beyond IEEE Std 603.	The same as in case with IEEE Std 603 considered above. Standard 6, Section 7.1 requires putting a mark “NPP” in the operational documentation of technical means of safety classes 1,2 and 3. Such marking the technical means is not obligatory.
5.12	**Auxiliary features** No requirements beyond IEEE Std 603.	The same as in case with IEEE Std 603 considered above.
5.13	**Multi-unit stations** No requirements beyond IEEE Std 603.	The same as in case with IEEE Std 603 considered above.
5.14	**Human factors considerations** No requirements beyond IEEE Std 603.	The same as in case with IEEE Std 603 considered above.

5.15	**Reliability** Additional requirement is that proof of the meeting the reliability goals shall include software used with the hardware.	Standard 6, Section 4.1.3 contains similar requirement. **Generally speaking, as it was mentioned above during a comparison of the IEEE 603, the Russian Standards 1-4 give more detailed and strict requirements for reliability of I&C for reactor control and protection systems. In addition to the Standards 1-4 requirements** Standard 6: • **Introduces detailed list of reliability parameters to be used for reliability calculation** for each type of nuclear control and diagnostic systems (Sections 4.1.6, 4.2.2); • **Applies the mentioned above parameters for purchased I&C means, including exported** ones (Section 4.2.3); • **Establishes a mean lifetime for nuclear I&C systems as minimum 30 years, and for their components (devices, channels etc.) as minimum10 years** provided their replacement is possible (Section 4.2.4); • **Requires confirmation of reliability data** during commissioning and first year of operation (Section 4.1.8).

3.5 Functional and design requirements to sense and command features

Table 6. Comparison of the functional and design requirements to sense and command features

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
6.	**SENSE AND COMMAND FEATURES - FUNCTIONAL AND DESIGN REQUIREMENTS** No requirements beyond IEEE Std 603	The same as in case with IEEE Std 603 considered above.

3.6 Functional and design requirements to execute features

Table 7. Comparison of the functional and design requirements to execute features

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
7.	**EXECUTE FEATURES (FUNCTIONAL AND DESIGN REQUIREMENTS)** No requirements beyond IEEE Std 603	The same as in case with IEEE Std 603 considered above.

3.7 Power sources requirements

Table 8. Comparison of the requirements to power sources

Section #	Main sense of the IEEE standard term, requirement or statement to be compared	What corresponds/differs in the standards applied in Russia
8.	**POWER SOURCE REQUIREMENTS** No requirements beyond IEEE Std 603.	Standard 6, Sections 2.8.2 –2.8.4 require the following. **Interruption of power supply for a time not more than 20 ms shall not lead to appearance of false commands and/or messages as well as computer reset and memory loosing** for the I&C systems of safety classes 1,2 and 3. Functioning the systems of safety class 4 after power supply interruption for a time not more that 20 ms shall automatically restore within pre-described period of time. Power supply voltage fast changes in the range from –25% up to +25% of rated value shall not cause reactor trip signal generation (for systems of safety class 1). The rest is the same as in case with IEEE Std 603 considered above.

4. Conclusion

The IEEE Std 7-4.3.2-1993 standard specifies only additional specific requirements to supplement the criteria and requirements of the IEEE Std 603-1998 when digital computers are used in safety systems. It is just amplifying criteria for computers in safety systems.

Unfortunately, there are no full analogues to IEEE Std 7- 4.3.2, which are amplifying specific criteria for computers in safety systems, among the Russian standards. The closest Russian analogue Standard 6 partially covers the same aspects for nuclear reactor I&C.

The conducted comparison has shown that in some cases, the criteria and requirements introduced by the IEEE Std 7-4.3.2 are strict enough and even stricter than ones given in the Russian analogue. An example is additional requirement on “Equipment qualification” (Table 5, item 5.4).

However, in number of important cases the Russian standard introduces much more detailed and stricter requirements, for example, it:

- Introduces detailed list of reliability parameters to be used for reliability calculation for each type of nuclear control and diagnostic systems (Sections 4.1.6, 4.2.2);
- Establishes a mean lifetime for nuclear I&C systems as minimum 30 years, and for their components (devices, channels etc.) as minimum10 years provided their replacement is possible (Section 4.2.4);
- Requires confirmation of reliability data during commissioning and first year of operation (Section 4.1.8);
- Limits a usage of the operating systems in safety important systems (Section 3.1.8);
- Requires that protection setpoints shall be realized by fixed hardware or firmware only (Section 3.2.5).

Finally, one may conclude that credit can be given to the safety systems based on digital computers, which are designed in accordance with the IEEE Std 7-4.3.2 requirements. Nevertheless, this cannot be done automatically without special expertise of the safety systems on compliance with the requirements of the Russian standards.

부록 IV

한-러 계측제어 규제요건 검토:

전자기파 기기검증 설계기준

Comparison of the Standards applied to NPP I&C design in Korea and Russia

Comparison of the U.S.NRC REGULATORY GUIDE 1.180 “Guidelines for Evaluating Electromagnetic and Radio – Frequency Interference in Safety – Related Instrumentation and Control Systems” for Nuclear Power Plants (applied in Korea)

And

Analogues (similar) standards applied in Russia

Prepared by expert (indicate name of the main author and his firm name)

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1. Introduction

Safety and effectiveness of operation of Nuclear Power Plants (NPP) highly depends on parameters and reliability of equipment and systems used.

The units of NPP are branched set of buildings, constructions, power stations and substations with voltages from 5 V to 750 kV (Figure 1).

Fig. 1. Units of NPP with WWER – 1000 reactors

At the same time, contemporary electronic elements based on microprocessor techniques are more and more used in the control of technological processes. The operation of microprocessor techniques in powerful electrical and magnetic fields is a typical feature of contemporary power generating objects.

One of the most important problems to be solved for providing safety and reliable operation of NPP units is the problem of decreasing (eliminating) influence of electromagnetic disturbances (interferences) on normal operation of the equipment (systems) used.

Operational experience of domestic and foreign objects shows that operating irregularities accompanying by unauthorized shutdowns of NPP units are possible at the impact of natural and man-caused electromagnetic disturbances.

Listed below relates to the most hard natural and man-caused electromagnetic disturbances, harmfully impacting the functioning of NPP units equipment and systems:

Lightning discharges

Lightning discharges on air terminals can cause risks of breakdown through a nonmetal wall between lightning conductor and grounded box bodies of power equipment (hereinafter: PE); risks of formation of high voltages on cable screens and in ground circuits if contact with grounding connections is bad; risks of formation of powerful pulsed magnetic fields on PE boxes and of induction of interference currents on power supply cables, data transmission lines, control and protection circuits; risks of breakdown of fiber-optic galvanic isolations of input signal and control circuits. As a result, there can occur “failures on demand”, when PE cannot fulfill functions set by instructions, or “failures on unauthorized actions”, when PE fulfills actions at the absence of instructions for these actions.

Switching disturbances

Switching disturbances arise at commutations of powerful loads in circuits of reliable power supply of PE of control systems or at operational manipulations with disconnectors and high-voltage switchers nearby PE boxes, e.g. nearby regulation system of excitation of electric generators.

They are disturbances of high-frequency type with an amplitude up to 4 kV, and they can propagate through power supply circuits, control and protection circuits, data transmission lines both conductively and inductively – from the surrounding space.

Switching disturbances can contribute to unauthorized actuation of emergency protections or shutdown of NPP units emergency unloading.

Dynamic changes of voltage and frequency in power supply network

Dynamic changes of voltage and frequency in power supply network can arise at backup supply emergency actuation or in emergency regime of operation of power generating systems, and these changes can disturb normal regime of operation of NPP units.

Electrostatic discharges

Electrostatic discharges of operating staff to box bodies can, due to their high-frequency character, easily penetrate through inductive and capacitive couplings directly to elements of equipment control circuits and, as the experience shows, can result in unauthorized switching on (switching off) actuators of NPP units.

Radiofrequency electromagnetic fields

The immunity of PE to radiofrequency electromagnetic fields is regulated by standards in a frequency range of 0.15 to 80 MHz – for conductive radiofrequency interference currents, and in a frequency range of 80 to 1000 MHz and a frequency range of 1400 to 2000 MHz – for radiofrequency electromagnetic field formed by radio-communication means, including mobile radiotelephones.

As the experience of NPP units operation shows, the use of mobile radiotelephones can result in formation of false signals incorrectly characterizing PE condition and in unauthorized NPP units unloading.

Magnetic fields of industrial frequency

Magnetic fields of industrial frequency in premises of power generating objects during their normal operation mainly influence equipment containing measuring devices based on magnetic field measurement.

Impact of magnetic fields on video displays of automated instrumentation and control systems of NPP units contributes to unstable images on display screens, that tires operator’s eyes and indirectly influences safety of NPP units.

In condition of short circuits in a power supply network, power cables form powerful short-time magnetic fields of industrial frequency, which impact on video displays results in change in color spectrum of chosen format of energy-release monitoring in technological circuit presented on the display, that, in its turn, results in disinformation of operational staff.

Pulsed magnetic fields

The nature of formation of pulsed magnetic fields is connected with the commutation of powerful loads or with lightning discharges.

Their mechanism of impact on PE is similar to the impact mechanism of magnetic fields of industrial frequency.

Interference currents in circuits of protection and signal grounding

Operational quality of PE directly depends on resistance of grounding connections (GC), influencing the value of voltage difference between both ground circuits. Voltage drop on GC may impact on data transmission cables, control and protection circuits of PE, contributing to unauthorized formation of signals for movement of actuators in directions, which are dangerous for technological processes.

Quality of power supply network

Distortion of sinusoid shape in power supply network caused by high harmonics of voltage or by current changes may result in overheating and damages of transformer windings and, as a result, in failures of PE functioning.

In addition to aforementioned natural and man-caused electromagnetic impacts, so called intentional power impacts (IPI) are considered in domestic and foreign literature. IPI means intentional formation of powerful pulses of voltage in power supply network, in information and control cables, grounding circuits, or formation of powerful radio-frequency pulse with amplitudes of voltage or electric force, duration and power, which can disturb PE operation or result in its degradation.

Fig. 2. Control room of NPP unit

Foreign specialists pay great attention to the creation of disturbance-resistant PE, in particular for power generating objects.

For example, failure-safe and failure-resistant approach is used in the United Kingdom at the creation of Instrumentation and Control Systems for emergency protection of Nuclear Power Plants. This equipment needs keeping its parameters with high accuracy at the impact of strong electromagnetic disturbances. Technical documentation for PE should include requirements on electromagnetic compatibility depending on PE destination and its influence on the safety of power generating object. These requirements regulate PE operation in order to exclude false actuation of emergency protection or unauthorized switching on power regulation of NPP units at the impact of electromagnetic disturbances.

It is known that the immunity of PE degrades with time of operation. In the United Kingdom a two-year interval is introduced in all NPPs between on-site tests on the compliance of PE with the normative requirements on electromagnetic compatibility, in order to reveal abnormalities or hidden failures of PE due to the degradation of characteristics of its components with time of operation. The following document is used for similar Russian NPP: “An order of the assessment of immunity of elements of instrumentation and control systems to electromagnetic disturbances at the modernization and prolongation of operation of these systems in Nuclear Power Plants”. The document determines methodology and procedure of control of PE longevity parameters with respect to providing their immunity to standardized electromagnetic disturbances, depending on destination of PE and its influence on safety of power generating object. A criterion is the estimation of immunity margin of PE, which has worked out its resource, to electromagnetic disturbances and timely taken measures increasing this margin.

At present safety-related equipment and systems are supplied both to Russian NPP from abroad and from Russia to foreign NPP. Therefore it is very important to harmonize the electromagnetic compatibility requirements of similar equipment and systems for Russian and foreign NPP.

It is generally accepted that obvious success in the field of technical regulation of electromagnetic compatibility (EMC) have been by now achieved in countries-members of the European Union (EU), where mandatory requirements have been introduced to provide the immunity of facilities of industrial and other applications to external electromagnetic disturbances, as well as to provide limitation of industrial radio-frequency disturbances emission within the norms.

Mandatory confirmation of the compliance of facilities used in national economy with the requirements on EMC is carried out in EU countries since 1st January 1996, that ensures rights of users, decreases contamination of environment with electromagnetic disturbances and, at the same time, excludes export into countries-EU members of facilities not meeting the requirements of European standards on EMC. A number of European electrotechnical (EN) and telecommunication (ETS) standards on EMC have been developed and introduced in order to regulate activity in the field of EMC.

By now, most countries (excluding USA and, seems, Korea) either have fully or partially accepted European mechanism of EMC technical regulation, or use and take into account in their industries the European standards on EMC.

Reorganization of domestic system of technical regulation in the field of EMC is mainly being carried out with the consideration of clauses of European system of technical regulation, and in connection with the future Russia joining the World Trade Organization.

Federal low "About technical regulation" #184-F3 of December 27, 2002, aimed at gradual transition of domestic system of technical regulation from fully centralized one to a legal system of technical regulation, typical for states with market economy, was put into legal validity on July 1, 2003.

This Federal low establishes a norm that mandatory requirements and confirmation procedures for compliance with these requirements shall be stated for production, which is dangerous for citizens' health, for their property and for the environment. The development and acceptance of two types of technical regulations – general technical regulations and special technical regulations – is a condition of establishing these requirements and confirmation procedures.

Federal low "About technical regulation" states that all problems of electromagnetic compatibility shall be covered by general technical regulations, which requirements shall be mandatory for all types of technical facility, containing electrical and electronic components. This means that after putting general technical regulation on electromagnetic compatibility into legal validity, technical facilities (including components, equipment, installations and systems) shall be developed and produced in accordance with the requirements established in general technical regulation on EMC, which is aimed at the exclusion of operating irregularities of these facilities at the impact of electromagnetic disturbances in real operating conditions.

Special technical regulations establish requirements to that types of products, industrial processes, operation, storage, transportation and recovery (e.g. nuclear wastes), for which purposes, stated in federal low "About technical regulations", could not be achieved by meeting the requirements of general technical regulations.

General technical regulations on EMC shall be developed on the basis of international standards on EMC, in order to follow legal norms of federal low "About technical regulations", which are equivalent to norms of EU Council Directives 89/336 of 03.05.1989 "About coordination of legislative acts of community members regarding electromagnetic compatibility".

As for particularly dangerous industries, such as nuclear and radiation dangerous objects including NPP, it shall be taken into consideration that aside from electromagnetic compatibility, nuclear and radiation safety shall be provided.

Features of these industries shall be taken into account in special technical regulations developed on the basis of standards on the corresponding products.

One of these standards is Russian standard GOST R 50746-2000, which is based on Russian GOST R 51317…standards requirements, which are in their turn harmonized with general requirements of basic International (mostly) and European standards of series IEC 61000, IEC 61508, EN, ETS, CISPR and, in addition to them, this standard regulates requirements on the immunity to electromagnetic disturbances depending on the equipment destination and its influence on NPP safety, as well as depending on a degree of severity of surrounded electromagnetic condition (Table 1).

Table 1. Manufacture grades on disturbance immunity of nuclear equipment

Category of nuclear equipment depending on its influence on the NPP safety	Manufacture grades of nuclear equipment concerning its disturbance immunity depending on the severity class of electromagnetic environment (EME) in premises where the equipment is allocated			
	Low EME	Medium EME	Hard EME	
Safety elements (systems)	III	IV	*	*
Safety-related elements (systems)	II	III	IV	*
Safety non-related elements (systems)	I	II	III	IV

Notes

1 Symbol "*" designates special manufacture grade of nuclear equipment, for which the requirements could be stronger than these for the equipment of the IV-th manufacture grade.

2 Qualitative parameters for the classification of the severity of electromagnetic conditions in premises for the allocation of nuclear equipment are given in Annex B of GOST R50746-2000.

Table 2. The harmonized Russian and International electromagnetic compatibility standards

№№	Russian standards	The title of standards	International standards
1	2	3	4
1.	GOST R 50746-2000	Electromagnetic compatibility of technical equipment. Technical equipment for nuclear power plants Requirements and test methods.	NWIP under consideraion TC-45A/TC77C IEC
2.	GOST R 51317.4.5-99	Electromagnetic compatibility of	IEC 61000-4-5-95

№№	Russian standards	The title of standards	International standards
1	2	3	4
		technical equipment. Microsecond high energy pulse disturbance immunity. Requirements and test methods.	
3.	GOST R 51317.4.11-99	Electromagnetic compatibility of technical equipment. Immunity to dynamic changes of power supply voltage. Requirements and test methods.	IEC 61000-4-11-94
4.	GOST R 51317.4.4-99	Electromagnetic compatibility of technical equipment. Immunity to electrical fast transient/burst. Requirements and test methods.	IEC 61000-4-4-95
5.	GOST R 51317.4.2-99	Electromagnetic compatibility of technical equipment. Immunity to electrostatic discharge. Requirements and test methods.	IEC 61000-4-2-95
6.	GOST R 51317.4.3-99	Electromagnetic compatibility of technical equipment. Radiated, radio-frequency, electromagnetic field immunity. Requirements and test methods.	IEC 61000-4-3-95
7.	GOST R 50648-94	Electromagnetic compatibility of technical equipment. Power frequency magnetic field immunity. Requirements and test methods.	IEC 61000-4-8-93
8.	GOST R 50649-94	Electromagnetic compatibility of technical equipment. Pulse magnetic field immunity. Requirements and test methods.	IEC 61000-4-9-93
9.	GOST R 51317.4.6-99	Electromagnetic compatibility of technical equipment. Immunity to conducted disturbance induced by radio- frequency fields. Requirements and test methods.	IEC 61000-4-6-96
10.	GOST R 51317.4.12-99	Electromagnetic compatibility of technical equipment. Oscillatory waves immunity.	IEC 61000-4-12-96

№№	Russian standards	The title of standards	International standards
1	2	3	4
		Requirements and test methods.	
11.	GOST R 51317.4.14-2000	Electromagnetic compatibility of technical equipment. Immunity to power voltage fluctuations. Requirements and test methods.	IEC 61000-4-14-99
12.	GOST R 51317.4.16-2000	Electromagnetic compatibility of technical equipment. Immunity to conducted disturbances in the frequency range OHz to 150 kHz. Requirements and test methods.	IEC 61000-4-16-98
14.	OST 36417.4.1-2001	Electromagnetic compatibility of technical equipment. Harmonics and interharmonics, including mains signaling at a.c. power port, low frequency immunity. Requirements and test methods.	IEC 61000-4-13-98
15.	GOST R 50652-94	Electromagnetic compatibility of technical equipment. Damped oscillatory magnetic field immunity. Requirements and test methods.	IEC 61000-4-10-93
16.	GOST R 51318.22-99	Electromagnetic compatibility of technical equipment. Manmade radio disturbance from information technology equipment. Limits and test methods.	CISPR 22-97
17.	GOST R 51318.11-99	Electromagnetic compatibility of technical equipment. Radio disturbance from industrial, scientific, medical and domestic (ISMD) radio-frequency equipment. Limits and test methods.	CISPR 11-97
18.	GOST R 51318.24-99	Electromagnetic compatibility of technical equipment. Immunity of information technology equipment. Requirements and test methods.	CISPR 24 -97

№№	Russian standards	The title of standards	International standards
1	2	3	4
19.	GOST R 51317.3.2-99	Electromagnetic compatibility of technical equipment. Harmonic current emissions. Limits and test methods.	IEC 61000-3-2-95
20.	GOST R 51317.3.3-99	Electromagnetic compatibility of technical equipment. Voltage fluctuations and fliker impressed on low-voltage supply systems by electromagnetic compatibility of technical equipment. Limits and test methods.	IEC 61000-3-3-94
21.	GOST R 50745-99	Electromagnetic compatibility of technical equipment. Uninterruptible power systems. Suppression devices of power mains pulse interferences. Requirements and test methods.	EN 50091-2-96
22.	GOST R 51317.6.4-99	Electromagnetic compatibility of technical equipment. Emission from technical equipment intended for use in industry environments. Limits and test methods.	IEC 61000-6-4-97
23.	NWIP on the basis of GOST R 50746-2000	Electromagnetic compatibility. Part 1: General – Section 2: Methodology for the achievement of functional safety of electrical and electronic equipment	IEC 61000-1-2
24.	NWIP on the basis of GOST R 50746-2000	Functional safety of electrical/electronic/programmable electronic safety – related systems (Part 1 – Part 7)	IEC 61508(1-7)
25.	NWIP on the basis of GOST R 50746-2000	High power electromagnetic effects on civilian systems.	IEC 61000-1-5
26.	NWIP on the basis of GOST R 50746-2000	Generic standard – High power electromagnetic immunity for indoor equipment.	IEC 61000-6-6

№№	Russian standards	The title of standards	International standards
1	2	3	4
27.	it. 4.2.1.13 GOST R 50746-2000	Electromagnetic compatibility of NPP equipment. Immunity to current disturbances of 50 Hz frequency in earthing circuits.	—
28.	it. 4.2.1.14 GOST R 50746-2000	Electromagnetic compatibility of NPP equipment. Immunity to pulse current disturbances in earthing circuits.	—

Table 3. The International Nuclear Event Scale for prompt communication of safety significance

LEVEL	DESCRIPTOR	CRITERIA	EXAMPLES
ACCIDENTS 7	MAJOR ACCIDEN	• External release of a large fraction of the reactor core inventory typically involving a mixture of short and long-lived radioactive fission products (in quantities radiologically equivalent to more than tens of thousands terabecquerels of iodine-131). Possibility of acute health effects. Delayed health effects over a wide area, possibly involving more than one country. Long-term environmental consequences.	Chernobyl, USSR 1986
6	SERIOUS ACCIDENT	• External release of fission products (in quantities radiologically equivalent to the order of thousands to tens of thousands of terabecquerels of iodine-131). Full implementation of local emergency plans most likely needed to limit serious health effects.	Kyshtym, USSR, 1957
5	ACCIDENT WITH OFF-SITE RISKS	• External release of fission products (in quantities radiologically equivalent to the order of hundreds to thousands of terabecquerels of iodine-131). Partial implementation of emergency plans (e.g. local sheltering and/or-evacuation) required in tonic cases to lessen the likelihood of health effects. • Severe damage to large fraction of the core due to mechanical effects and/or melting.	Windscale, UK 1957 Three Mile Island, USA, 1979
4	ACCIDENT MAINLY IN INSTALLATION	• External release of radioactivity resulting in a dose to the most exposed individual off-site of the order of a few millisieverts.* Need for off-site protective actions generally unlikely except possibly for local food control. • Some damage to reactor core due to mechanical effects and/or melting. • Worker doses that can lead to acute health effects (of the order of 1 Sievert).**	Greate Britain, 1973 Saint-Laurent, France, 1980 Argentina, 1983
INCIDENTS	SERIOUS INCIDENT	• External release of radioactivity above authorized limits, resulting in a dose to the most exposed individual off site of the	Vandellos, Spain

LEVEL	DESCRIPTOR	CRITERIA	EXAMPLES
3		order of tenths of a millisievert.* Off-site protective measures not needed. • High radiation levels and/or contamination on-site due to equipment failures or operational incidents. Overexposure of workers (individual doses exceeding 50 millisieverts).** • Incidents in which a further failure of safely systems could lead to accident conditions, or a situation in which safety systems would be unable to prevent an accident if certain initiators were to occur.	1989
2	INCIDENT	•Technical incidents or anomalies which, although not directly or immediately affecting plant safely, are liable to lead to subsequent re-evaluation of safely provisions.	
1	ANOMALY	•Functional or operational anomalies which do not pose a risk but which indicate a lack of safety provisions. This may be due to equipment failure, human error or procedural inadequacies. (Such anomalies should be distinguished from situations where operational limits and conditions are not exceeded and which are properly managed in accordance with adequate procedures. These are typically "below scale".)	
BELOW SCALE/ZERO	NO SAFETY SIGNIFICANCE		

** The doses art expressed in terms of effective dose equivalent (whole body dose). Those criteria where appropriate also can be expressed in terms of corresponding annual effment discharge limitsits authorised by National authorities.*

*** These doses are also expressed, for simplicity, in terms off effective dose equivalents (sieverts), although the doses in the range involving acute health effects should be expressed in terms of absorbed dose (grays).*

In Russian standard GOST R 50746-2000 quality function criteria A, B, C are connected with the degrees of incidents evaluated by International Nuclear Event Scale (INES-table 2.3).

For example, criterion B is acceptable for safety-related systems if deviations in operational quality parameters from that given in a specification (or technical regulations of an NPP) could not result in NPP incidents of a level, higher then “O” according to the INES.

Clauses of standard GOST R 50746-2000 and their distinguished features are basis for the development of Russian special technical regulation.

During the IEC TC 45 meeting, which took place in Beijing in October 2002 with the participation of Russian experts, a problem was considered on the inclusion of the development of an international standard of electromagnetic compatibility for the equipment, delivered for nuclear dangerous objects including NPP, into the work plan of subcommittee SC45A in order to create a uniform approach to strict differentiation of EMC requirements to facilities, depending on their destination and influence on the safety, when these facilities are delivered for foreign or Russian objects.

It was proposed during this meeting that Russian national committee for IEC would submit a “New Work Item Proposal” based on the clauses of Russian standard GOST R 50746-2000.

The consideration of this problem with the participation of Russian specialists was continued in Lausanne in February 2003 during the meeting of IEC subcommittee SC 77C. The participants of the meeting approved the submission of a New Work Item Proposal, and this work was proposed to be carried out by SC45A in cooperation with SC77B and SC77C in order to consider a possibility of the inclusion into the standard of recommendation on testing facilities important to safety on their immunity to intentional power impacts on the basis of standards IEC 61000-1-5 and IEC 61000-6-6.

The proposal of Russian national committee on the development of international standard "Nuclear Power Plants – Instrumentation and control systems important to safety – Requirements for electromagnetic compatibility testing" was considered in October 2003 in Montreal during the meeting of IEC TC 45 (Now 45A/527/NP).

The purpose of this standard is to provide needed criteria and requirements for EMC testing for equipment and systems important to safety of Nuclear Power Plants.

Requirements on the immunity of equipment and systems to intentional power impacts on power supply networks, information and control circuits and grounding circuits were proposed to be included into the standard as recommendations.

It was decided to carry out this work in cooperation with IEC SC77B, SC 77C, CISPR, CENELEC-NC210, CIGRE.

The results of the NWIP (45A/527/NP) IEC voting are indicated below

The comments was received on 2004-04-29. Korea did not take part in this voting to our regret.

Closing Date: 2004-05-14

IEC – Voting Results

Country	Status	Received	Support	CD	CDV	Participation	Comments
Belgium	P	2004-04-06	Y	Y	N	N	-
Canada	P	2004-05-03	N	N	N	N	Y
China	P	2004-04-29	Y	Y	N	N	-
Czech Republic	P	2004-03-31	Y	Y	N	N	-
Finland	P	2004-05-07	Y	Y	N	N	-
France	P	2004-04-29	N	N	N	N	Y
Germany	P	2004-05-13	N	N	N	N	Y
Italy	P	2004-05-14	Y	Y	N	N	-
Japan	P	2004-04-30	Y	Y	N	Y	Y
Portugal	-	2004-05-13	A	N	N	N	-
Russian Fed.	P	2004-05-14	Y	Y	N	Y	Y
South Africa	P	2004-05-14	Y	Y	N	N	-
Sweden	P	2004-04-29	N	N	N	N	Y
Switzerland	P	2004-03-04	Y	Y	N	Y	-

Country	Status	Received	Support	CD	CDV	Participation	Comments
U.S.A.	P	2004-05-12	Y	Y	N	Y	Y
Ukraine	P	2004-04-30	Y	Y	N	N	-
United Kingdom	P	2004-05-11	N	N	N	N	Y

Fig. 3. Screened anechoic test chamber

2. Acronyms

In this section the used abbreviations and terms shall be spelled. For example, the following acronyms are used in this report:

NPP	Nuclear power plant
EMC	Electromagnetic compatibility
PE	Power equipment
GC	Grounding connection
IPI	Intentional power impacts
EU	European Union
EN	European norms
IEC	International electrotechnical commission
NRC	U.S. nuclear regulatory commission
ETS	European telecommunication standard
CISPR	International Special Committee for Radio Interference
EME	Electromagnetic environment
TC	Technical committee
SC	Subcommittee
MIL – STD	U.S. Military standard
I&C	Instrumentation and Control
CE	Conducted emission
RE	Radiated emission
CS	Conducted susceptibility
RS	Radiated susceptibility
EMI	Electromagnetic interferences
RFI	Radio – Frequency interferences
CD	Committee Draft
CDV	Committee Draft for Voting

3. Comparison of the standards

3.1 References

This subsection is devoted to list the standards applied for Russian NPPs, which are selected for comparison with the given U.S. NRC Regulatory Guide 1.180.

Table 4. List of the standards selected for comparison

Regulatory Guide and standards applied in Korea to be compared with Russian analogues	Standards applied in Russia selected for comparison
1. U.S. NRC Regulatory Guide 1.180 “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems” applied in Korea and based on the standards: MIL-STD-461E; IEEE Std 1050-1996; IEEE Std C62.41-1991; IEEE Std C62.45-1992; IEC 61000-3…; IEC 61000-4…; IEC 61000-6-4-97	1. GOST R 50746-2000 “Electromagnetic compatibility of technical equipment. Technical equipment for nuclear power plants. Requirements and test methods” based on Russian basic and generic EMC standards GOST R 51317.3-…-99; GOST R 51317.4-…-99; GOST R 51318-…-99; GOST R 50648-94; GOST R 50649-94; GOST R 50652-94; GOST R 51317.6.4-99. 2. GOST R 50745-99 “Electromagnetic compatibility of technical equipment. Uninterruptable power systems. Suppression devices of power mains pulse interferences. Requirements and test methods”. 3. IEC 61000-1-2 “Electromagnetic compatibility. Part 1: General, Section 2: Methodology for the achievement of functional safety of electrical and electronic equipment”. 4. IEC 61508 (1-7) “Functional safety of electrical/electronic/programmable electronic safety-related systems. Part 1 – Part 7. 5. IEC 61000-1-5 “High power electromagnetic effects on civilian systems”.

Standards 1 and 2 are selected for comparison because they are the main product standards created in Russia for EMC certificate tests of NPP safety and safety – related equipment (systems). The standard 1 establishes the norms of emission and the requirements of the immunity to electromagnetic disturbances depending on equipment (systems) destination and its influence on NPP safety, as well as depending on a degree of severity of surrounded electromagnetic environment. The standards 1 and 2 use the test methods described in Russian standards GOST R 51317.3…; GOST R 51317.4…; GOST R 51318…; GOST R 50648; GOST R 50649; GOST R 50652; GOST R 51317.6.4, which are harmonized with International standards IEC 61000-3…; IEC 61000-4…; IEC 61000-6-4 and European standard EN 50091-2.

Supplementary standards 3 and 4 are pointed because they concern the functional safety of NPP safety and safety – related equipment (systems) during their operation under electromagnetic disturbances, Risk assessment using ALARP Principle described in IEC 61508-5 and Safety assessment using INES Scale, described in IAEA Guide “International Nuclear Event Scale”.

Standard 5 concerns the test norms and methods for assessment of safety and safety – related equipment (systems) immunity to intentional power electromagnetic impacts.

3.2 Scope (Section 1)

Table 5.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	A	Guidance for complying with NRC's regulations on design, installation and testing practices for addressing the effects of electromagnetic and radio-frequency interference and power surge on NPP safety-related instrumentation and control (I&C) systems, including power leads and signal leads, located at control rooms, remote shutdown panels, cable spreading rooms, equipment rooms, auxiliary instrument rooms and other areas, including the turbine desk, where NPP safety-related I&C system installations are planned.	Requirements to NPP safety-related instrumentation and control (I&C) equipment (systems) together with power leads, communication lines, grounding mats, premises for the placement of nuclear I&C equipment in order to ensure electromagnetic compatibility including the requirements to electromagnetic disturbance immunity and norms for disturbance emission as well as the corresponding test methods during its development, design, operation and modernization. The standard GOST R 50746-2000 applies to electrical, electronic and radio-electronic production (including electric actuators of different application) as well as production containing electric, electronic and radio-electronic components (circuits) supplied for nuclear establishments (NPP I&C equipment/systems).

3.3 Definitions (Section 2)

Table 6.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
2	None	None	Dynamic change of supply voltage (drop, interruption, variation) Disturbance of NPP I&C equipment being a short-time deviation of supply voltage behind the regulated lower or upper limits, with a length from one half-cycle of alternating current frequency to several second, with the subsequent return to its initial value.
	None	None	Nanosecond impulse disturbance Impulse disturbance of nuclear I&C equipment with a length within the limits of one nanosecond to one microsecond
	None	None	Microsecond impulse disturbance Impulse disturbance of nuclear I&C equipment with a length within the limits of one microsecond to one millisecond
	None	None	Degree of severity of nuclear I&C equipment tests on disturbance immunity Conditional number reflecting the intensity of a disturbance applied having parameters regulated by normative documentation
	None	None	Quality criterion of the operating nuclear I&C equipment during the tests on disturbance immunity A collection of properties and parameters characterizing operating of nuclear I&C equipment at the impact of disturbances
	None	None	Severity of electromagnetic environment at the place of nuclear I&C equipment allocation Generalized characteristic of electromagnetic environment depended on the intensity of conductive and emitted disturbances existing at the place of nuclear I&C equipment allocation and stipulated by the condition, installation and mounting.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/stateme nt to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	None	None	<u>Functional quality criteria nuclear I&C equipment at the tests on disturbance immunity</u> A* – Normal operational in correspondence with the specification of nuclear I&C equipment of specific type. B* – Nuclear I&C equipment operates normally after the cessation of a disturbance exposure. The disturbance causes a short-time malfunction of the nuclear I&C equipment with the subsequent restoration of normal operation after the cessation of a disturbance exposure. C* – A temporary nuclear I&C equipment malfunction which needs an intervention by operator for the restoration of normal operation after the cessation of a disturbance exposure. * Note: – Nuclear I&C equipment belonging to safety or safety-related systems shall meet quality criterion A for operation of all types of electromagnetic disturbances. – Criterion B is acceptable for safety-related systems if deviations in operational quality parameters from that given in a specification (or technical regulations of an NPP) could not result in NPP incidents of a level, higher that "0" according to the International Nuclear Event Scale (INES). – If nuclear I&C equipment belongs to non-safety-related systems of normal operation, selected types of testing impacts and criteria A or B (C) of operational quality at the tests on disturbance immunity are determined on an agreement between supplier and purchaser.
	None	None	<u>Arrangement groups I, II, III, IV, special of equipment performances</u> They are used for characterizing equipment immunity to electromagnetic disturbances. The groups will be established depending on product destination and its influence on the NPP safety and also depending on the severity of the environment.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/stateme nt to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	None	None	Accepted criteria and modes To determine the correspondence to required specifications of NPP I&C equipment and its possible faults and failures under disturbances in different operational modes which can make negative influence to functional safety of I&C equipment, causing to dangerous consequences: – no operation when required (e.g. refusal of input of neutron rods in reactor cores) – “request failures” – operation when no operation should be occurred (e.g. unauthorized withdrawal of neutron rods from reactor cores) – “failures causing to unauthorized operation” – deviation from intended operation (e.g. failures of process of units unloading or decrease of neutron flux) – “failures causing to violations in normal operation”

3.4 EMC test norms of the standards for NPP safety-related systems situated in typical industrial (medium) electromagnetic environment

Table 7.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
3	3 Table 2	MIL-STD-461E “Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment”, U.S. Department of Defense, August 20, 1999: CE 101 (conducted emission) 30 Hz to 10 kHz CE 102 (conducted emission) 10 kHz to 2 MHz RE 101 (radiated emission) 30 Hz to 100 kHz RE 102 (radiated emission) 2 MHz to 1 GHz	None None None None
	3 Table 3	IEC 61000-6-4 “Electromagnetic compatibility (EMC) – Part 6: Generic Standards, Section 4: Emission Standard for Industrial Environments”, 1997: Conducted emission 30 Hz to 10 kHz CISPR 11 (conducted emission) 150 kHz to 30 MHz Radiated emission 30 Hz to 100 kHz	GOST R 51317.6.4-99 (harmonized with IEC 61000-6-4-97) “Electromagnetic compatibility of technical equipment. Emission from technical equipment intended for use in industry environments. Limits and test methods”: None GOST R 51318.11-99; GOST R 51318.22-99 150 kHz to 30 MHz None

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	Table 3	CISPR 11 (radiated emission) 30 MHz to 1 GHz	GOST R 51318.11-99; GOST R 51318.22-99 30 MHz to 1 GHz Note: Standard GOST R 51318.11-99 “Electromagnetic compatibility of technical equipment. Radio disturbance from industrial, scientific, medical and domestic (ISMD) radio-frequency equipment. Limits and test methods” is harmonized with CISPR 11-97 “Industrial, Scientific, and Medical Radio-Frequency Equipment – Electromagnetic Disturbance Characteristics – Limits and Methods of Measurement”, International Special Committee on Radio Interference, 1997 Standard GOST R 51318.22-99 “Electromagnetic compatibility of technical equipment. Manmade radio disturbance from information technology equipment. Limits and test methods” is harmonized with CISPR 22-97 “Information technology equipment. Radio disturbance characteristics. Limits and methods of measurement”, 1997.
	3.5 Table 4 dBμV: dBμV: dBμV:	IEC 61000-6-4 Conducted Emission Envelopes (CISPR 11 Class A) 150 kHz to 500 kHz (79 quasi-peak, 66 average) 500 kHz to 5 MHz (73 quasi-peak, 60 average) 5 MHz to 30 MHz (73 quasi-peak, 60 average)	GOST R 51317.6.4-99 Conducted Emission Envelopes (Class A) GOST R 51318.11-99/GOST R 51318.22-99 150 kHz to 500 kHz (79 quasi-peak, 66 average) 500 kHz to 5 MHz (73 quasi-peak, 60 average) 5 MHz to 30 MHz (73 quasi-peak, 60 average)

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	3.5 Table 5 dBμV/m: dBμV/m:	IEC 61000-6-4 Radiated Emission Envelopes (CISPR 11 Class A) 30 MHz to 230 MHz (30 quasi-peak, at 30 m) 230 MHz to 1 GHz (37 quasi-peak, at 30 m)	GOST R 51317.6.4-99 Radiated Emission Envelopes (Class A) GOST R 51318.11-99/GOST R 51318.22-99 30 MHz to 230 MHz (30 quasi-peak, at 30 m) 230 MHz to 1 GHz (37 quasi-peak, at 30 m)
	4 Table 6 4.1.1 dBμV: 4.1.2 dBμA: 4.2 Table 14 dBμA: Table 14 Table 14	MIL-STD-461E EMI/RFI Susceptibility Test Methods CS101 Conducted susceptibility on power leads except grounds and neutrals: 30 Hz to 150 kHz (Fig. 4.1) 126 for 30 Hz to 5 kHz ≤ 28 V 136 for 30 Hz to 5 kHz > 28 V 126 to 96 linear for 5 kHz to 150 kHz ≤ 28 V 136 to 106 linear for 5 kHz to 150 kHz > 28 V CS114 Conducted susceptibility 10 kHz to 30 MHz on power leads: (Fig 4.2) 100 for 10 kHz to 200 kHz 97 for 200 kHz to 30 MHz on interconnecting signal leads: 91 for 10 kHz to 30 MHz CS115 Conducted susceptibility, bulk cable injection, impulse excitation on signal leads: 2 A CS116 Conducted susceptibility,	None None None None

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
		damped sinusoidal transients 10 kHz to 100 MHz on signal leads: 5 A	
	4.3 Table 17 4.3.1 dBpT: 4.3.2	RS101 Radiated susceptibility, magnetic field 30 Hz to 100 kHz on equipment: (Fig. 4.3) 180 to 110 linear RS103 Radiated susceptibility, electric field 30 MHz to 1 GHz on equipment: 10 V/m	None None

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	4 Table 7 4.2 Table 15 Table 16 5 Table 22	IEC 61000-4-series EMI/RFI Susceptibility Test Methods Conducted susceptibility, electrically fast transients/bursts by: IEC 61000-4-4-95 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 4: Electrical Fast Transient/Burst Immunity Test”, 1995 <u>on signal leads:</u> Level 3: 1 kV (Low EME) Level 4: 2 kV (Medium EME) <u>on power lines:</u> Level 3: 2 kV (Low EME) Level 4: 4 kV (Medium EME) <u>Note:</u> The same levels are used in standard: IEEE Std C62.41-1991 “IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits” Institute of Electrical and Electronics Engineers, issued 1991, reaffirmed 1995.	GOST R 50746-2000 “Electromagnetic compatibility of technical equipment. Technical equipment for nuclear power plants. Requirements and test methods”. i.4.2.1.3 Immunity to nanosecond pulse disturbances according to GOST R 51317.4.4-99 harmonized with IEC 61000-4-4-95 method. <u>on signal leads:</u> Group III: 1 kV (Medium EME) Group IV: 2 kV (Hard EME) <u>on power lines:</u> Group III: 2 kV (Medium EME) Group IV: 4 kV (Hard EME)
	4 Table 7	Conducted susceptibility, surges by: IEC 61000-4-5-95 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 5: Surge Immunity Test”, 1995	GOST R 50746-2000 i.4.2.1.1 Immunity to microsecond pulse disturbances of large energy according to GOST R 51317.4.5-99 harmonized with IEC 61000-4-5-95 method.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	4.2 Table 15 Table 16 5 Table 22	on signal leads: Level 2: 1 kV open circuit test voltage (Low EME) Level 3: 2 kV open circuit test voltage (Medium EME) on a.c. power lines: Level 3: 2 kV open circuit test voltage (Low EME) Level 4: 4 kV open circuit test voltage (Medium EME) Note: The same levels are used in standard: IEEE Std C62.41-1991 “IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits” Institute of Electrical and Electronics Engineers, issued 1991, reaffirmed 1995.	on signal leads: Group III: 1 kV (Medium EME) Group IV: 2 kV (Hard EME) on a.c. power lines: Group III: “wire-to-wire”: 1 kV (Medium EME) “wire-to-ground”: 2kV (Medium EME) Group IV: “wire-to-wire”: 2 kV (Medium EME) “wire-to-ground”: 4 kV (Hard EME)
	4 Table 7 4.2 Table 15 Table 16	Conducted susceptibility, disturbances induced by radio-frequency fields by: IEC 61000-4-6-96 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 6: Immunity to conducted disturbance induced by Radio-Frequency Fields”, 1996 on signal leads: Level 2: 130 dBμV (3 V) test voltage (Low EME) Level 3: 140 dBμV (10 V) test voltage (Medium EME)	GOST R 50746-2000 i.4.2.1.8 Immunity to electromagnetic interference induced by radio-frequency electromagnetic fields according to GOST R 51317.4.6-99 harmonized with IEC 61000-4-6-95 method. on signal and power lines: Group III: 140 dBμV (10 V) test voltage (Medium EME) Group IV: 140 dBμV (10 V) test voltage (Hard EME)

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	4 Table 7	Conducted susceptibility, 100 kHz ring wave by: IEC 61000-4-12-96 "Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 12: Oscillatory Waves Immunity Tests", 1996	GOST R 50746-2000 i.4.2.1.9 Immunity to oscillatory damped disturbances according to GOST R 51317.4.12-99 harmonized with IEC 61000-4-12-96 method.
	4.2 Table 15 Table 16 5 Table 22	on signal leads: Level 2: 1kV test voltage (Low EME) Level 3: 2 kV test voltage (Medium EME) on a.c. power lines: Level 3: 2 kV (Low EME) Level 4: 4 kV (Medium EME) Note: The same levels are used in standard: IEEE Std C62.41-1991 "IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits" Institute of Electrical and Electronics Engineers, issued 1991, reaffirmed 1995.	on input lines of a.c./d.c. power supply: Group III (Medium EME): "wire-to-wire": 1 kV "wire-to-ground": 2 kV Group IV (Hard EME): "wire-to-wire": 2 kV "wire-to-ground": 4 kV on output lines of a.c./d.c. power supply: Group III (Medium EME): "wire-to-wire": 0,5 kV "wire-to-ground": 1 kV Group IV (Hard EME): "wire-to-wire": 1 kV "wire-to-ground": 2 kV

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	4 Table 7 4.1.3 Table 10	Conducted susceptibility, low frequency, 16 Hz to 2,4 kHz by: IEC 61000-4-13-98 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 13: Immunity to Harmonics and Inter-harmonics”, 1998. on a.c. power lines: – harmonics – 2 to 39; – % of supply voltage – 1,5 to 8 depending on harmonics; – voltage level – 1,7 to 3,2 depending on supply voltage.	GOST R 50746-2000 i.4.2.1.15 Immunity to a distortion of power supply voltage harmonicity according to OST 36417.4.1-2001 harmonized with IEC 61000-4-13-96 method. Degrees of severity of tests of nuclear I&C equipment on disturbance immunity in conditions of a distortion of power supply voltage harmonicity at the impact of harmonics and inter-harmonics of power supply voltage are given in depending on: – odd harmonics, non-divisible by 3; – odd harmonics, divisible by 3; – even harmonics; – harmonic components with frequencies allocated between frequencies of harmonics.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	4 Table 7 4.1.3 Table 11 Table 11 Table 11	Conducted susceptibility, low frequency, 15 Hz to 150 kHz by: IEC 61000-4-16-98 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 16: Test for Immunity to Conducted, Common Mode Disturbances in the Frequency, Range 0 Hz to 150 kHz”, 1998. on d.c. and a.c. power leads: – dc/power line frequency, continues disturbance: Level 3: 10 Vrms – dc/power line frequency, short duration disturbance: Level 3: 100 Vrms - conducted disturbance: Level 3: 10 – 1 Vrms (15 – 150 Hz) 1 Vrms (150 Hz – 1,5 kHz) 1 – 10 Vrms (1,5 – 15 kHz) 10 Vrms (15 – 150 kHz)	GOST R 50746-2000 i.4.2.1.11 Immunity to electromagnetic interference with a frequency band of a 0 to 150 kHz according to GOST R 51317.4.16-2000 harmonized with IEC 61000-4-16-98 method. The requirements should be established only for nuclear I&C equipment being composite elements of electrical installation of significant power. on d.c. and a.c. power leads: – long-time (50 Hz) Group III (Medium EME): 10 V Group IV (Hard EME): 30 V – short-time (50 Hz) Group III (Medium EME): 30 V Group IV (Hard EME): 100 V – conducted (15 Hz – 150 kHz) Group III (Medium EME): 10 – 1 Vrms (15 – 150 Hz) 1 Vrms (150 Hz – 1,5 kHz) 1 – 10 Vrms (1,5 – 15 kHz) 10 Vrms (15 – 150 kHz) Group IV (Hard EME): 30 – 3 Vrms (15 – 150 Hz) 3 Vrms (150 Hz – 1,5 kHz) 3 – 30 Vrms (1,5 – 15 kHz) 30 Vrms (15 – 150 kHz)

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	4 Table 7 4.3.3 Table 19 Table 19	Radiated susceptibility, magnetic field, 50 Hz by: IEC 61000-4-8-93 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 8: Power Frequency Magnetic Field Immunity Test”, 1993 <u>Continuous pulses:</u> Class 4 (Level 3): 30 A/m – (Medium EME) <u>Shot duration pulses:</u> Class 4 (Level 3): 300 A/m – (Medium EME)	GOST R 50746-2000 i.4.2.1.6 Degree of severity of tests on the immunity to magnetic field of mains frequency according to GOST R 50648-94 harmonized with IEC 61000-4-8-93 method. <u>Long-time magnetic field:</u> Group III: 30 A/m (Medium EME) Group IV: 40 A/m (Hard EME) <u>Short-time magnetic field (3s):</u> Group III: 400 A/m (Medium EME) Group IV: 600 A/m (Hard EME)
	4 Table 7 4.3.3 Table 19	Radiated susceptibility, magnetic field, 50 Hz to 50 kHz by: IEC 61000-4-9-93 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 9: Pulse Magnetic Field Immunity Test”, 1993 Class 4 (Level 3): 300 A/m – (Medium EME)	GOST R 50746-2000 i.4.2.1.7 Immunity to pulse magnetic field according to GOST R 50649-94 harmonized with IEC 61000-4-9-93 method. Group III: ± 300 A/m (Medium EME) Group IV: ± 600 A/m (Hard EME)
	4 Table 7 4.3.3 Table 19	Radiated susceptibility, magnetic field, 100 kHz to 1 MHz by: IEC 61000-4-10-93 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 10: Damped Oscillatory Magnetic Field Immunity Test”, 1993 Class 4 (Level 3): 30 A/m – (Medium EME)	GOST R 50746-2000 i.4.2.1.16 Immunity to a damped oscillatory magnetic field according to GOST R 50652-94 harmonized with IEC 61000-4-10-93 method. Group III: 30 A/m (Medium EME) Group IV: 100 A/m (Hard EME)

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	4 Table 7 4.3.3	Radiated susceptibility, electric field, 26 MHz to 1 GHz by: IEC 61000-4-3-95 “Electromagnetic Compatibility. Part 4: Testing and Measurement Techniques. Section 3: Radiated, Radio-Frequency, Electromagnetic Field Immunity Test”, 1995 Level 3: 10 V/m – (Medium EME)	GOST R 50746-2000 i.4.2.1.5 Immunity to radio-frequency electromagnetic field according to GOST R 51317.4.3-99 harmonized with IEC 61000-4-3-95 method. 80 – 1000 MHz: Group III: 10 V/m (Medium EME) Group IV: 10 V/m (Hard EME) 800 – 960, 1400 – 2000 MHz: Group III: 30 V/m (Medium EME) Group IV: 30 V/m (Hard EME)
	None	None	GOST R 50746-2000 i.4.2.1.14 Immunity to electrostatic discharges according to GOST R 51317.4.2-99 harmonized with IEC 61000-4-2-95 method. contact discharge: Group III: ± 6 kV (Medium EME) Group IV: ± 8 kV (Hard EME) air discharge: Group III: ± 8 kV (Medium EME) Group IV: ± 15 kV (Hard EME)
	None	None	GOST R 50746-2000 i.4.2.1.10 Immunity to fluctuations of voltage of power supply according to GOST R 51317.4.14-2000 harmonized with IEC 61000-4-14-99 method. on ac power lines: Group III: ± 12 % U_n (Medium EME) Group IV: ± 20 % U_n (Hard EME)

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	None	None	GOST R 50746-2000 i.4.2.1.12 Immunity to variation of frequency in power supply systems according to GOST R 51317.4.28-2000 harmonized with IEC 61000-4-28-99 method. on ac power lines: Group III: ± 15 % $\Delta f/f_1$ (Medium EME) Group IV: ± 15 % $\Delta f/f_1$ (Hard EME)
	None	None	GOST R 50746-2000 i.4.2.1.13 Immunity to currents of shot-time sinusoidal disturbances with a frequency of 50 Hz in circuits of protective and signal grounding. The International methods are unknown. between protective and signal lines of grounding: Group III: 150 A (Medium EME) Group IV: 200 A (Hard EME)
	None	None	GOST R 50746-2000 i.4.2.1.14 Immunity to currents of microsecond pulse disturbances in protective and signal grounding circuits. The International methods are unknown. between protective and signal lines of grounding: duration of wave front: 4 ± 30 % µS duration of pulse current:300 ± 20% µS Group III: ± 150 A (Medium EME) Group IV: ± 200 A (Hard EME)

<table>
<tr><th>#</th><th>Section number</th><th>Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared</th><th>What corresponds in the standards applied in Russia</th></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td></td><td>None</td><td>None</td><td>GOST R 50746-2000
i.4.3.2 Norms for harmonic components of consumption current according to GOST R 51317.3.2-99 harmonized with IEC 61000-3-2-95 method.
<u>on ac power lines:</u>
Nuclear I&C equipment with a consumption current of less than 16 A (per phase) feeding from a common electricity supply network with a nominal voltage of 220/380 V shall meet emission norms for harmonic components of consumption current:
<u>Class A:</u>
<table>
<tr><th>Odd harmonics</th><th>I, A</th></tr>
<tr><td>3</td><td>2,30</td></tr>
<tr><td>5</td><td>1,14</td></tr>
<tr><td>7</td><td>0,77</td></tr>
<tr><td>9</td><td>0,40</td></tr>
<tr><td>11</td><td>0,33</td></tr>
<tr><td>13</td><td>0,21</td></tr>
<tr><td>15≤ n ≤ 39</td><td>0,15 15/n</td></tr>
<tr><th>even harmonics</th><th>I, A</th></tr>
<tr><td>2</td><td>1,08</td></tr>
<tr><td>4</td><td>0,43</td></tr>
<tr><td>6</td><td>0,30</td></tr>
<tr><td>8≤ n ≤ 40</td><td>0,23 15/n</td></tr>
</table>
</td></tr>
</table>

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	None	None	GOST R 50746-2000 i.4.3.3 Norms of voltage variations caused by nuclear I&C equipment according to GOST R 51317.3.3-99 harmonized with IEC 61000-3-3-94 method. on ac power lines: Nuclear I&C equipment with a consumption current of less than 16 A (per phase) feeding from a common electricity supply network with a nominal voltage of 220/380 V shall meet the following norms for voltage variations in the electricity supply network, caused by nuclear I&C equipment: – steady relative variation of voltage – 3 % – maximum relative variation of voltage – 4 % – characteristics of relative variation of voltage – less than 3 % for time interval of voltage variation exceeding 0,23
	None	None	GOST R 50745-99 harmonized with EN 50091-2-96 “Electromagnetic compatibility. Uninterruptable power systems. Suppression devices of power mains pulse interferences” norms and methods.

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	None	None	IEC 61000-1-2 "Electromagnetic compatibility. Part 1: General. Section 2: Methodology for the achievement of functional safety of electrical and electronic equipment" is used as the informative guide. It will be included in NWIP 45A/527/NPSC45A-IEC "Nuclear power Plants – Instrumentation and Control Systems important to safety – Requirements for electromagnetic compatibility testing".
			IEC 61000-1-2 specifies a methodology for the achievement of functional safety of I&C equipment with regard of EMC phenomena and gives guidance to designers manufacturers and installers of I&C equipment and systems
	None	None	IEC 61508-5 "Functional safety of electrical/electronic/programmable electronic safety-related systems. Part 5: Examples of methods for the determination of safety integrity levels". It is suggested to use "ALARP and tolerable risk concepts" together with "Insignificant risks" of event consequences according to INES. (Annex 1). It will be included in NWIP 45A/527/NP SC45A-IEC

#	Section number	Main sense of U.S. NRC Regulatory Guide 1.180 requirements/statement to be compared	What corresponds in the standards applied in Russia
1	2	3	4
	None	None	IEC 61000-1-5 "High power electromagnetic effects on civilian systems". It is proposed to use the methods of this standard in I&C equipment/systems testing for immunity to intentional power effects (electromagnetic terrorism). Immunity norms for testing of I&C equipment/systems are under consideration in Russian national committee now. Both norms and methods are proposed to be included in NWIP 45A/527/NP SC45A-IEC.
	<u>Note to Table 7:</u> Below there is an additional information about IEC standards mentioned above: – IEC 61000-4-2-95 "Electromagnetic compatibility. Part 4: Testing and Measurement Techniques. Section 2: Electrostatic Discharge Immunity Test", 1995 – IEC 61000-4-14-99 "Electromagnetic compatibility. Part 4: Testing and Measurement Techniques. Section 14: Voltage Fluctuation Immunity Test", 1999 – IEC 61000-4-28-99 "Electromagnetic compatibility. Part 4: Testing and Measurement Techniques. Section 28: Variation of Power Frequency Immunity Test", 1999 – IEC 61000-3-2-95 "Electromagnetic compatibility. Part 3-2: Limits – Limits for Harmonic Current Emissions", 1995 – IEC 61000-3-2-94 "Electromagnetic compatibility. Part 3-3: Limits – Limitation of Emission of Voltage Changes, Voltage Fluctuations and Flicker in public Low – Voltage Supply Systems for Equipment with Rated Current not more than 16 A (per phase), 1994.		

4. Conclusion

The following general notes concerning the compared standards for electromagnetic compatibility testing of I&C equipment/systems can be given:

- U.S. Regulatory Guide 1.180 uses the requirements and methods of MIL, IEEE and IEC standards for safety-related I&C systems EMC testing. The Guide regulates requirements of an immunity to electromagnetic disturbances depending on a degree of severity of electromagnetic environment of I&C equipment/systems allocation.

- Russian GOST R 50746-2000 uses the methods of Russian GOST R 51317, GOST R 51318 standards harmonized with IEC 61000-4, IEC 61000-3 for safety-related I&C equipment/systems EMC testing. MIL and IEEE standard are not used for EMC testing of safety-related I&C equipment/systems for Russian and foreign NPP.

Standard GOST R 50746-2000 regulates requirements of the immunity to electromagnetic disturbances depending on the equipment destination and its influence on NPP safety, as well as depending on a degree of severity of electromagnetic environment of I&C equipment allocation.

In Russian standard GOST R 50746-2000 quality function criteria A, B, C are connected with the degrees of incidents evaluated by International Nuclear Event Scale (INES). Risk and Safety assessment are based on ALARP Principle of IEC 61508-5 and INES.

- Russian GOST R 50746-2000 in comparison with U.S. NRC Regulatory Guide 1.180 contains more types of requirements to EMC immunity of safety-related I&C equipment/systems, which are practically founded on the experience of Russian NPP operation.

- At present the NWIP "Nuclear Power Plants – Instrumentation and control systems important to safety – Requirements for electromagnetic testing" (45A/527/NP) is under consideration in SC45A – IEC.

The purpose of the NWIP to create an uniform approach to strict differentiation of EMC requirements to facilities, depending on their destination and influence on NPP safety, when these facilities are delivered for Russian or foreign NPP.

Besides it is proposed to include in this NWIP requirements of I&C equipment/systems functional safety to immunity to intentional (terrorist) electromagnetic impacts, to immunity to high-altitude nuclear electromagnetic pulses.

Final conclusion concerning mutual certification of safety-related I&C equipment/systems designed in Korea and Russia can be made as following:

- Generally, the U.S. NRC Regulatory Guide 1.180 EMC requirements are strict enough but not comprehensive as compared with Russian standard GOST R 50746-2000 for NPP safety-related I&C equipment/systems.

- To harmonize the EMC requirements of safety-related I&C equipment/systems for Russian and foreign NPP the EMC immunity requirements and emission norms of standards IEC 61000-4(-2-95; -14-2000; -28-2000), IEC 61000-3(-2-95; -3-94), EN 50091-1-2, could be added to U.S. NRC Regulatory Guide 1.180 as normative, but IEC 61000-1-2, IEC 61508-5, IEC 61000-1-5 as informative.

- To evaluate risk and I&C systems functional safety it is recommended to use the ALARP Principle of IEC 61508-5 and International Nuclear Event Scale (IAEA, Vienna, Austria).

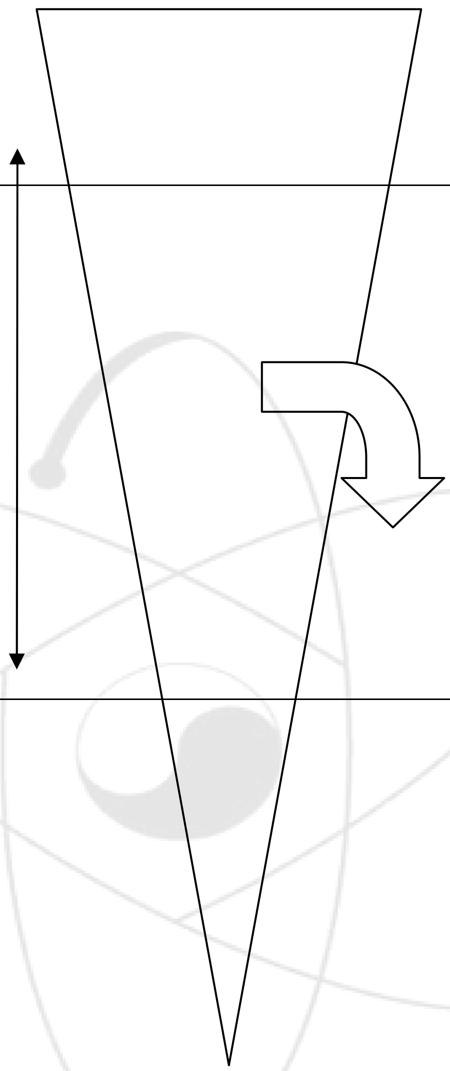
Risk and Safety Assessment

ALARP Principle IEC 61508-5, INES Scale.

R I S K

I. Intolerable region

Risk cannot be justified except in extraordinary circumstances



II. The ALARP or tolerable region

Tolerable only if further risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained

III. Risk is undertaken only if a benefit is desired

As the risk is reduced, the less, proportionately, it is necessary to spend to reduce it further to satisfy ALARP. The concept of diminishing proportion is shown by the triangle

IV. Broadly acceptable region

It is necessary to maintain assurance that risk remains at this level

No need for detailed analysis to demonstrate ALARP

Negligible risk

Insignificant risk

Power equipment performance criteria	Event consequences according to INES			
	< 0	0	1	2
A	IV	IV	-	-
B	III	II	I	I
C	III	II	I	I

< 0 – non safety-related

0 – non safety-significant

1 – departure from authorized mode of operation

2 – incidents with deficient safety measures

부록 V

한-러 계측제어 규제요건 검토:

전기기기 내진 검증 기준

Comparison of the Standards applied to NPP I&C design in Korea and Russia

Comparison of the ANSI/IEEE 344-1987 "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations" (applied in Korea) And Analogues (similar) standards applied in Russia

Prepared by expert (indicate name of the main author and his firm name)

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Checked by expert-auditor

Igor Rakitin, RRC "Kurchatov Institute", Moscow, Russia

Table of Contents

1. Introduction

This section is devoted to list all standards applied for Russian NPPs, which are selected for comparison with the given IEEE standard, and briefly explain why they are selected.

Table 1.

IEEE Standard applied in Korea to be compared with Russian analogues	Standards applied in Russia, selected for comparison
ANSI/IEEE 344-1987 “IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations” (applied in Korea)	Main document (used for comparison): 1. NP-031-01 “Norms for design of earthquake-proof NPPs” Supplementary documents (mentioned in comparison): 2. GOST 17516.1-90 “Electrical articles. General requirement for environment mechanical stability” 3. GOST 16962.2-90 “Electrical articles. Test methods as to environment mechanical factors stability” 4. IEC 60980

Standard 1 is selected for comparison because it is the last proved and active regulatory document concerning aseismic design of NPPs.

Supplementary documents 2 and 3 are pointed because they concern also the object of qualification in ANSI/IEEE 344-1987, and Standard 1 in implementation of its statements implicitly or explicitly touches these documents. Standard 3 is pointed because it is officially published in Russia and after the implementing a law “About technical regulation” it became one of documents which also concerns the object of qualification in ANSI/IEEE 344-1987 and can be used in implementation of statements of Standard 1.

2. Acronyms

The following acronyms are used in this report:

ERS − experience response spectrum

MRZ − maximal rated earthquake (Russian)

NPP − nuclear power plant

OBE − operating basis earthquake

PSD − power spectral density

RRS − required response spectrum

PZ − design earthquake (Russian)

SSE − safe shutdown earthquake

TRS − test response spectrum

ZPA − zero period acceleration

3. Comparison of the standards

3.1. Scope and References (Section 1)

Table 2.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
1.	1.1 Scope	Qualification procedures of Class 1E equipment for operation during and following one safe shutdown earthquake (SSE) preceded by a number of operating basis earthquakes (OBE).	Demands to new overland NPPs (including buildings, structural units and foundations, technological and electro-technical equipment, pipelines, instruments, other systems and elements of NPP) (Standard 1, Section 1). Equipment is also categorized relatively to their seismic stability to I, II and III category (Standard 1, Section 2.6.1).
2.	1.2 References	Main definitions in this document and ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.	Terms see item 3.

3.2. Definitions (Section 2)

Table 3.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
3.	2.	broadband response spectrum	No.
4.		coherence function	No.
5.		correlation coefficient function	No.
6.		cutoff frequency	No.
7.		damping	No (Standard 1, Main terms and definitions); relative damping (Standard 2, Annex 6).
8.		flexible equipment	No.
9.		floor acceleration	all-floor accelerogram (Standard 1, Main terms and definitions)
10.		Fourier spectrum	No.
11.		ground acceleration	earthquake accelerogram (Standard 1, Main terms and definitions)
12.		narrowband response spectrum	No.
13.		natural frequency	No (Standard 1, Main terms and definitions); eigen frequency (Standard 2, Annex 6)
14.		operating basis earthquake (OBE): could reasonably be expected during the operating life of the plant. All systems remain functional systems should remain functional	Similar to: design earthquake (PZ) – the earthquake of maximal intensity with repetition once in 1000 years (Standard 1, Main terms and definitions).
15.		power spectral density (PSD)	No.
16.		qualified life	No (Standard 1, Main terms and definitions); usually: “service life” in all technical standards
17.		required response spectrum (RRS)	No.
18.		resonant frequency	No (Standard 1, Main terms and definitions); common term for all technical standards

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
19.		response spectrum	response spectrum (Standard 1, Main terms and definitions)
20.		rigid equipment	No.
21.		safe shutdown earthquake (SSE): maximum regional earthquake. Certain systems remain functional ensuring (1) the integrity of the reactor coolant pressure boundary (2) the shut down the reactor and maintaining it in a safe shutdown condition (3) the prevention of off-site exposures	Similar to: maximal rated earthquake (MRZ) – the earthquake of maximal intensity with repetition once in 10000 years (Standard 1, Main terms and definitions).
22.		sine beats	No.
23.		stationarity	No.
24.		test response spectrum (TRS)	No.
25.		transfer function	No.
26.		zero period acceleration (ZPA)	No.
27.			Note: Seismic "stability" (Standard 1, Main terms and definitions; Standard 2, Section 1.1 of Annex 6; Standard 3, Section 2.1.1) means "the property to keep an ability to perform predefined functions during earthquake" and is similar to behavior implied in IEEE 344, but and "proofness" (Standard 1, Section 6.2, 6.3; Standard 2, Annex 6, Section 1.1; Standard 3, Section 2.1.2) as "the property to resist destructive vibrations and to keep an ability to perform predefined functions after earthquake" differs from "fragility" used in IEEE 344.

3.3. General Discussion of Earthquake Environment and Equipment Response (Section 3)

Table 4.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
28.	3.	Provides background information on earthquake behavior and on the performance of equipment during simulated seisic events.	Main statements about the structure of NPP design – data about NPP site seismicity, calculations of seismic stability of buildings and equipment, design of anti-seismic preventive measures (Standard 1, Section 2.1, 2.5, 2.8, 2.11-2.17); NPP site seismicity– data about PZ and MRZ (Standard 1, Section 2.2, 2.3); NPP seismic stability– the property to keep the safety at earthquakes of MRZ level and to keep the energy production at earthquakes of PZ level (Standard 1, Section 2.4, 2.6, 2.9-2.10); categorization of NPP elements: – I class – responsible for safety, II class – responsible for energy production and other safety related, and III class – all others (Standard 1, Section 2.6, 2.7). No general discussions about earthquake nature and responses.
29.	3.1 Earth-quake Environment	Ground motions: approximately as simultaneous statistically independent horizontal and vertical components with strong motion portion from 10 s to 15 s over a frequency range of 1 Hz–33 Hz.	NPP site seismicity (Standard 1, Section 2.4, 2.6, 2.9-2.10, and expressly Section 3, Annex 1-3) – as definition of MRZ and PZ levels and other characteristics of earthquake using standard norms (at financial start stage) and real data (at project design stage).
30.	3.2 Equipment on Foundations	Usually multiple-frequency excitation.	Definition of seismic characteristics of buildings, structural units and foundations (Standard 1, Section 4, Annex 4) – the methodology of buildings design and seismic characteristics calculation as the simple modeling of buildings; expressly application for equipment using all-floor accelerograms (Standard

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
			1, Section 4.10).
31.	3.3 Equipment on Structures	Most frequently narrow band or single-frequency excitation.	Definition of seismic characteristics of technological equipment and pipelines without discussing the nature of characteristics, as stability to seismic effect of MRZ or PZ level, sometimes with direct demands to admissible tensions in elements (Standard 1, Section 5, Annex 5-6).
32.	3.4 Simulating the Earthquake	Simulation of earthquake by analysis or testing can be described by (1) Response spectrum or (2) Time history or (3) PSD, supplied as a part of the equipment specification	Initial data – all-floor accelerograms and response spectra for places of equipment installation (Standard 1, Section 5.2, 6.8).
33.	3.4.1 Response Spectrum	Response spectrum as the maximum response of single-degree-of-freedom oscillators as a function of oscillator frequency and damping. Important note: it does not contain (1) the waveform or time history (2) the duration of motion (3) the response of any particular equipment with-out its dynamic characteristics.	Amplification factor spectrum, response spectrum, all-floor response spectrum, generalized response spectrum (Standard 1, Main terms and definitions).
34.	3.4.2 Time History	Earthquake-induced motion as a function of time.	Accelerogram, analog accelerogram, earthquake accelerogram, response accelerogram, all-floor accelerogram, synthesized accelerogram (Standard 1, Main terms and definitions).

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
35.	3.4.3 Power Spectral Density Function	The mean squared amplitude per fre-quency unit.	No.

3.4. Seismic Qualification Approach (Section 4)

Table 5.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
36.		Equipment's ability to perform its safety function during a number of OBE and after one SSE. Methods for seismic qualification: (1) by analysis (2) by test (3) by a combination of test and analysis (4) by experience.	Seismic stability of NPP elements (Standard 1, Main terms and definitions) differs for elements of different categories (Standard 1, Section 2.9) – I class should be stable at MRZ, II class – at PZ (see 28).
37.		Notes: (1) the safety function during the earth-quake may differ from those ones required after the earthquake; the definition of the safety function should be provided as part of the equipment qualification specification; (2) the seismic testing should be per-formed in its proper sequence as part of an overall qualification program as indicated in ANSI/IEEE Std 323-1983 [2] taking into account aging mechanisms.	No. Some instruction – reference about a sequence of tests to GOST 16962.1 (Standard 3, Section 1.21).

3.5. Damping (Section 5)

Table 6.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
38.	5.1 Introduction	Damping as numerous energy dissipation mechanisms in a system. Notes about linear methods of analysis and real nonlinear constructions.	No.
39.	5.2 Measurement of Damping	Several methods of calculating of damping with the notes about possible inaccuracies: 5.2.1 Damping by Measuring the Decay Rate (logarithmic decrement method); 5.2.2 Damping by Measuring the Half-Power Bandwidth; 5.2.3 Damp-ing by Curve Fitting Methods.	Only general guide about justification of damping by special substantiations using calculations, modeling, experiments (Standard 1, Section 4.11). Measurement of damping by impact (Standard 3, Section 1 of Annex 2) and by free oscillations (Standard 3, Section 2 of Annex 2).
40.	5.3 The Application of Damping		
41.	5.3.1 The Application of Damping in Analysis	The prediction of the response to the seismic motion taking using linear or non-linear damping approximations.	No instructions in Standard 1; sufficiently detailed demands to design-experimental estimation of equipment (Standard 2, Section 2 of Annex 6).
42.	5.3.2 The Application of Damping in Testing	The test based on the peak response of an array of single-degree-of-freedom oscillators with 5% damping is offered in the RRS for testing, the comparison of the possible relations between the damping in the RRS and the TRS.	No clear instruction in Standard 1; accurate values of test accelerations (Standards 2, Section 1.3.1 of Annex 6).

3.6. Analysis (Section 6)

Table 7.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
43.		Method not recommended for complex equipment.	No instructions for equipment in Standard 1, absolutely definite method for building constructions (Standard 1, Annex 4), reservoirs with liquids (Standard 1, Annex 5) and for linear-lengthy construc-tions (Standard 1, Annex 6); only design-experimental estimation of equipment (Standard 2, Section 2 of Annex 6) means the absence of recommendations for equipment.
44.	6.1 Intro-duction	Two approaches – based on (1) dynamic analysis (2) on static coefficient analysis. General procedure is of the recommended analytical process: (1) Review the equip-ment to assess the dynamic characteristics (2) Determine the response using one or more of several methods described in the following sections (3) Determine the stresses and displacements that result from the response (4) Compare the calculated responses with those that ensure compli-ance with design requirements.	No.
45.	6.2 Dy-namic Analysis	The equipment and any secondary struc-tural supports are modeled for rigid and for flexible equipment using correspond-ingly simple multiplication or the square root of the sum of the square method (SRSS).	No.
46.	6.3 Static Coefficient Analysis	The acceleration response of the equip-ment is assumed to be the maximum peak of the RRS at a conservative and justifi-able value of damping with assurance co-efficient of 1.5.	No.
47.	6.4 Nonlinear Equipment	Significant non-linearities must be prop-erly accounted or testing could be re-quired.	No.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
	Response		
48.	6.5 Other Dynamic Loads	Other dynamic loadings – such as hydro-dynamic (see 7.1.6.1).	No.
49.	6.6 OBE and SSE Analysis	The number of OBE events (important only for low-cycle fatigue-sensitive equipment) shall be not less than one and shall be justified for each site or five OBE shall be used.	No.
50.	6.7 Docu-mentation of Analysis	The documentation shall include (1) the requirements or specifications (2) the re-sults of the qualification (3) the justifica-tion that the equipment can perform its safety function.	No.

3.7. Testing (Section 7)
Table 8.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
51.	7.1 Introduction	Test vibratory motion should conservatively simulates an earthquake.	In Standard 1 – only initial data about earthquake – all-floor accelerograms and response spectra for places of equipment installation (Standard 1, Section 5.2, 6.8), no clear logic transition to test actions; contrariwise, in Standard 2, 3 – only strict actions without comparison with earthquake nature.
52.		Testing approaches differ for (1) the equipment used in only one application (proof-testing) and (2) for the equipment used in many applications (generic testing) (see 7.2).	No. It means practically only one (Standard 1) and very wide (Standards 2, 3) idea for applications of the equipment. Exclusion in Standard 2, Section 7.
53.		Fragility testing for determination the limit of the equipment's capabilities (see 7.3).	No (see note in item 27).
54.		Special consideration for multidirectional effects (see 7.6.6).	Single-meaning instruction that all tests should be performed in three dimensions – simultaneously for elements of I Class and sequentially for elements of II Class (Standard 1, Section 2.13, 5.6), discussion about a possibility to test in three dimensions simultaneously or sequentially for different characteristics of element and testing method (Standard 3, Section 1.11, 1.12).
55.		For testing devices as part of complex equipment is recommended approach with the appropriate vibration input (RRS) at the locations were these	No clear instructions in Standard 1 (see comment to item 51); values of accelerations in places of installations (Standard 2,

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
		devices are in-stalled.	Annex 6).
56.		Note: an equipment that has been shaker-table tested should, in general, not be in-stalled in a plant without proof that the equipment has not degrade its ability to perform its safety function.	No.
57.	7.1.1 Mounting	The equipment to be tested shall be mounted on the vibration table in a man-ner that simulates the intended service mounting.	Equivalent (Standard 1, Section 6.4, 6.6), alternative variant – to test in lop-sided test table (Standard 3, section 1.12).
58.	7.1.2 Monitoring	Functional and vibrational response parameters must be monitored during vibration testing. The location of the vibration sensors and the functional monitoring systems shall be documented.	Partially: test loads are monitored on the mounting bottom of device (Standard 1, Section 6.6).
59.	7.1.3 Refurbishment	Any refurbishment during a test program should be classified into maintenance or repair according to its degree.	No.
60.	7.1.3.1 Maintenance	Maintenance shall be determined and documented in detail in the test reported and, when performed during OBE testing, should be included into the post earth-quake field maintenance checks and procedures.	No.
61.	7.1.3.2 Repairs	After necessary repairs during the OBE test and during or after the SSE test, generally the retest is required unless justified otherwise. When repairs are made, the details shall be included in the test report.	Test of operability and repair procedures should be envisaged (Standard 1, Section 2.11).

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
62.	7.1.4 Exploratory Tests	Exploratory vibration (low input level vibration tests) is used for the determination of the test qualification method for the dynamic characteristics of the equipment (resonance searches): (1) slow swept sinusoidal vibration test with uniaxial input (2) impacting in a controlled manner at critical points (3) by broadband random input signal	No in Standard 1; simultaneously with the measurement of damping – see 39 (Standard 3, Annex 2).
63.	7.1.4.1 Resonance Search by Base Excitation	Usually – a slowly swept low-level sinusoidal vibration, the sweep rate two octaves per minute, 0.2 g peak input, up to 50 Hz or to the RRS cutoff frequency. Resonance are detected by (2) amplifications of the input motion (2) phase relationships between the input and the response (3) combining amplification and phase data (4) low-level broadband random motion (by Fast Fourier Transform analysis of excitation and response time histories).	No.
64.	7.1.4.2 Resonance Search by Impedance Methods	Resonance search by exciting with a small portable shaker or by impact testing (see 8.2).	See item 62.
65.	7.1.4.3 Application of Resonance Search Data	The use for (1) design information (2) data for certain test methods (3) data for qualification efforts.	No in Standard 1; for definition of test method (Standard 2, Sections 1.5, 2.14 of Annex 6, etc.; Standard 3, Section 2, Section 2.2.2).
66.		When no resonances within the amplified range of the RRS – equipment should be considered rigid and analyzed or tested accordingly; when resonances exist or when the critical resonant frequencies cannot be ascertained – it should be tested (see 7.6).	See item 65.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
67.		Note: due to nonlinearities, resonance responses at high levels may differ in frequency and damping from those at low levels.	No.
68.	7.1.5 Vibrational Aging	SSE must be preceded by the number of OBE specified for each site and the equivalent fatigue effects of vibrations resulting from normal and transient plant operating conditions.	Nothing about SSE + OBE and aging. Tests with combined technological and seismic loads (Standard 1, Section 4.4, 5.4, 5.13, 6.7).
69.	7.1.5.1 Aging from Non-seismic Vibration Conditions	According to ANSI/IEEE Std 323-1983 [2]. Seismic tests loads should exceed the nonseismic vibration loads (See 7.6.5 and Appendix D).	See item 68.
70.	7.1.5.2 Seismic Aging (OBE)	OBE tests, preceding the SSE, should produce a number of equivalent maximum peak cycles (see 7.6.5).	No.
71.	7.1.6 Loading	Seismic qualification tests shall be performed in normal operating conditions (electric loads, mechanical loads, thermal loads, pressure, etc).	More detailed definition of seismic and technological loads (see items 57, 68).
72.	7.1.6.1 Hydro-dynamic Loads	For the equipment subjected to vibratory loads associated with SRV discharge and the loss-of-coolant accident (LOCA) must be evaluated under the simultaneous effects of the seismic and other vibratory loads.	Tests with combined technological and seismic loads (Standard 1, Section 5.4, 5.13).
73.	7.2 Proof and Generic Testing	Proof testing – for equipment qualification for a particular requirement (particular response spectrum, time history, or other parameters) – see 7.6. Generic testing – for equipment qualification to encompass most, or all, of the known requirements (wide frequency bandwidth with relatively high acceleration levels).	See item 52.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
74.	7.3 Fragility Testing	Fragility testing – for determination of the ultimate capability of equipment by a demonstration of its response to (1) sine beat (or transient) type excitation (2) continuous sine excitation (3) multifrquency wave-forms (see in 7.6 and Appendix C).	No.
75.	7.4 Device Testing	Tests should simulate operating conditions corresponding to either expected service requirements or their ultimate capability, including mounting.	Equivalent (see items 57, 68).
76.		The effects produced by impacts, rattling, chatter, or banging must be considered in qualification.	No.
77.	7.5 Assembly Testing	It is acceptable to test complex equipment in an inoperative mode with the actual or simulated devices installed including non-safety related devices on condition that the resulting vibration response of the de-vice at its location is not less than the vibration to which the device is qualified.	No in Standard 1; similar, using amplitude-frequency characteristics of stationary constructions in the place of element installation (Standard 2, Section 1.4 of Annex 6).
78.	7.6 Test Methods 7.6.1 Introduction	The methods for proof or generic testing (7.2) and fragility testing (7.3).	No in Standard 1 (see item 52).
79.		The types of motion: (1) single frequency and (2) multiple frequency.	No in Standard 1; in others: no single frequency, some similarity to test on proofness at fixed frequency (Standard 3, Section 2.2.9), other tests – only multi-frequency or at least at the collection of frequencies (Standard 3, Section 2.1.2).

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
80.		The test seismic simulation waveforms should (1) produce a TRS that closely envelops the RRS (2) have a peak acceleration equal to or greater than the RRS ZPA (3) not include frequency content above the RRS ZPA asymptote (4) have a duration in accordance with the requirements of 7.6.5.	No in Standard 1; nothing about TRS/RRS and ZPA, duration 1 min (Standard 2, Section 1.1 of Annex 6).
81.	7.6.1.1 Artificially Broadened Response Spectra	A testing procedure for a floor-level motion: the RRS is usually broadened to cover the uncertainty in the building structural frequency.	No.
82.	7.6.1.2 Test Response Spectrum Analysis	Recommendation: the TRS should be computed with 1/6 octave bandwidth resolution.	No.
83.	7.6.1.3 Damping Selection	Recommendation: the RRS with a damping of 5% (see 5.3.2).	No.
84.	7.6.2 Single-Frequency Test	Recommended for (1) one predominant frequency in mode the seismic ground motion (2) the equipment that has no resonances, or only one resonance, or resonances are widely spaced and do not interact.	See 79.
85.	7.6.2.1 Derivation of Test Input Motion	Generally, the test motion should produce a TRS acceleration at least equal to that given by the RRS, the peak input acceleration must be at least equal to the ZPA of the RRS except at low frequencies where the RRS goes below and stays be-low the ZPA for which the value of the RRS must be met.	No.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
86.	7.6.2.1.1	If the performance of equipment can be assessed by structural integrity alone: a TRS at the test frequency should be of 1.5 times that given by the specified RRS peak, and the TRS need not completely envelop the RRS.	No.
87.	7.6.2.1.2	If the performance of equipment must be assessed by the combination of structural integrity and operability: the precise vibratory nature and frequency content of the excitation with equipment responses with 1.5 factor, the TRS need not completely envelop the RRS, or single-frequency TRS should envelop the RRS at the equipment resonances.	No.
88.	7.6.2.2 Continuous-Sine Test	Continuous sinusoidal motion at the frequency (see 7.6.2.1) and amplitude (see 7.6.2.1) with a total duration and low-cycle fatigue potential (see 7.6.5).	No.
89.	7.6.2.3 Sine-Beat Test	Series of a number of cycles of motion (see 7.6.2.1) with a sufficient pause between each, the test frequencies (see 7.6.2.1), the total test duration and the low-cycle fatigue potential at any frequency (see 7.6.5).	No.
90.	7.6.2.4 Decaying-Sine Test	Single frequency of exponentially decaying amplitude. At least five decaying sinusoids at the frequency (see 7.6.2.1) and amplitude (see 7.6.2.1), the total test duration and low-cycle fatigue potential at any frequency (see 7.6.5), the degree of conservatism (see 7.6.2.2), with a sufficient pause between the sinusoids.	No.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
91.	7.6.2.5 Sine-Sweep Test	Sinusoidal input with continuously varying frequency in the range (see 7.6.2), the conservatism of the continuous-sine test (at typical sweep rates of two octaves per minute or less, the percentage of steady-state resonance response more than 90), the total sine-sweep test duration and equivalent maximum peak cycles (see 7.6.5), the maximum acceleration (see 7.6.2.1).	No.
92.	7.6.3 Multiple-Frequency Tests	The testing excitation includes random or complex time histories, depending on the frequency distribution necessary to simulate the required floor motion.	No.
93.	7.6.3.1 Derivation of Test Input Motion	Criteria for the testing motion: (1) the TRS envelops the RRS (2) the TRS is computed with a damping value equal to or greater than that of the RRS (see 5.3.2 and 7.6.1.2) (3) the shake-table maximum peak acceleration is at least equal to the ZPA of the RRS (See Appendix A) (4) the total test duration and low-cycle fatigue potential are as those in 7.6.5 (5) the time history indicates frequency content at least as broad as the amplified region of the RRS (6) the statistical parameters do not vary significantly throughout the test.	No.
94.	7.6.3.2 Time-History Test	Table motion should be developed so that its TRS envelops the RRS according to the general criteria of 7.6.3.1.	No.
95.	7.6.3.3 Random-Motion Test	The input (a random noise generator and multiple-channel filter combination, or multiple signals taped on individual channels of an analog tape recorder, or a digital computer program) to the shake table with each band (typically, 1/3 octave) is adjusted until the TRS envelops the RRS (see 7.6.3.1).	No.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
96.	7.6.3.4 Complex-Motion Tests	The summation of several different types of individual narrowband components superimposed on lower level broadband random motion whose TRS will envelop the RRS (see 7.6.3.1).	No.
97.	7.6.3.4.1 Random Motion with Sine Dwells	A broadband random motion similar to 7.6.3.3, the levels of individual frequency bands are adjusted and a sine dwells are added at each frequency until the RRS is enveloped by the TRS (see 7.6.3.1), with a peak input acceleration at least equal to ZPA and the duration of the sine dwell is made equal to the total test duration.	No.
98.	7.6.3.4.2 Random Motion with Sine Beats	Similar to that of 7.6.3.4.1 except that sine beats are used in place of sine dwells.	No.
99.	7.6.3.4.3 Combi-nation of Multiple Sinusoids	The summation of multiple sine waves (sinusoids) with distinct frequencies (spaced typically at 1/3 octave) that in-clude the resonant frequencies of the equipment up to the cutoff frequency, the enveloping criteria see 7.6.3.1.	No.
100.	7.6.3.4.4 Combination of Multiple Sine Beats	This motion is similar to that of 7.6.3.4.3 except that a series of sine beats at each distinct frequency is used in place of the sinusoids (criteria see in 7.6.3.1, 7.6.3.4.2, 7.6.3.4.3)	No.
101.	7.6.3.4.5 Combination of Decaying Sinusoids	Multiple (typically at 1/3 octave) decaying (decay rate over the damping range from 0.5% to 10%) sinusoids for a medium band-with TRS with a reasonably low ZPA, enveloping criteria see 7.6.3.1.	No.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
102.	7.6.4 Other Tests	Other vibration tests considering: (1) bandwidth of the RRS compared to that of the TRS and equipment characteristics and responses (2) duration of the test compared to the defined seismic event (3) peak acceleration of the test input and the magnification observed (4) natural modes and vibration frequencies of the equipment (5) typical equipment damping (6) fragility levels (7) low-cycle fatigue potential (8) the TRS must envelop the RRS (see 7.6.3.1).	No.
103.	7.6.5 Test Duration and Low-Cycle Fatigue Potetial	The duration of the strong motion portion of each test should at least be equal to the strong motion portion of the original time history, with a minimum of 15 s; the fatigue-inducing potential of the test wave-form should be at least equivalent to the strong motion portion of the earthquake response motion (see Appendix D).	See item 80.
104.	7.6.6 Multi-axis Tests		Usually 3-axis (Standard 1, Sections 4.8, 5.6), but no analysis for special cases.
105.	7.6.6.1 Single-Axis Tests	Usually, at the absence of significant motion in the other orthogonal directions and when an equipment has very low cross-coupling among all axes. The required OBE followed by the SSE is performed in each axis in sequence.	No. Some similar statement about the possibility to test only in one most dangerous direction (Standard 3, Section 1.11).
106.	7.6.6.2 Biaxial Tests	Usually, at the absence of significant motion in one orthogonal direction for independent input motions and when an equipment has very low cross-coupling among all axes. Test are performed in two or four steps OBE followed by the SSE in corresponding sequence.	See items 104, 105.
107.	7.6.6.3 Triaxial Tests	With a simulator capable of independent motions in all three orthogonal directions (See Appendix E).	See items 104, 105.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
108.	7.6.7 Line-Mounted Equipment	Usually, at the natural frequency of the mounting place of the component, and one-third octave frequency increments throughout the range of 2 Hz through 32 Hz, or higher, the test duration at each resonant frequency be the period of time required to establish full operability of the equipment or 10 s, whichever is longer.	No.
109.	7.7 Test Documentation	See Section 10.	-

3.8. Combined Analysis and Testing (Section 8)

Table 9.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
110.	8.1 Introduction	In cases of equipment complexity, dimensions and mass, or the large number of similar configurations.	Similar – it is acceptable to use combined method (Standard 1, Sections 6.2), especially in case of equipment complexity and others (Standard 1, 6.5; Standard 2, Section 2 of Annex 6).
111.	8.2 Modal Testing	Determination of resonant frequencies, mode shapes, and often as a lower bound for modal damping.	No in Standard 1; similar using local data on the place of element installation (Standard 2, Section 1.4 and 2 of Annex 6) – see item 77, or by principle of construction similarity with test justification (Standard 2, Section 2.1.2, 2.10, 2.11 and others of Annex 6).
112.	8.2.1 Normal-Mode Method	The structure should is excited (by port-able exciters attached to the structure) with a slowly swept sinusoidal vibration covering the frequency range of interest (measured by motion-sensing devices at previously determined points) to determine structural response.	No.
113.	8.2.2 Transfer-Function Method	The transfer-function method is based upon to measure the transfer function. Transfer functions between input and response locations on the structure are obtained by exciting the structure with an impulse, sine sweep, or random vibration and subsequent use of digital signal processing techniques and the fast Fourier transform algorithm.	No in Standard 1; similarly, using amplitude-frequency characteristics of stationary constructions in the place of element installation (Standard 3, Annex 2) – see item 77.
114.	8.2.3 Analytical Methods Utilizing Test Data	The use of the resulting measurement of dynamic response parameters for verification of analytical model of the equipment.	See item 111.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
115.	8.2.4 Qualification	Combined analysis and testing methods.	See item 111.
116.	8.3 Extrapolation for Similar Equipment	Qualification by combined test and analysis are applied.	See item 111.
117.	8.3.1 Test Method	A full test program (see 7.6) and preliminary exploratory (resonance search) tests (see7.1.3) are conducted on a typical piece of equipment.	No.
118.	8.3.2 Analysis	The test results combined with the pre-ceding analysis are used for consideration of the affected parametric quantities of the similar equipment.	No in Standard 1; similarly, using similarity principle based on tested equipment taking into ac-count the effect of changes (Standard 2, Section 2.1.3 of Annex 6).
119.	8.4 Shock Testing	The testing by high-impulse shock-type loads (accelerations) and an approximation of the adequacy of the equipment tested.	No.
120.	8.5 Extrapolation for Multi-cabinet Assemblies	The extrapolation of tests on a single cabinet, or a small number of connected cabinets, to qualify an assembly (see 8.3).	No.
121.	8.6 Other Test/Analysis	Other applications of analysis.	No.

3.9. Experience (Section 9)

Table 10.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
122.	9.1 Introduction	Qualification of similar equipment using comparison of the equipment characteristics and of the excitation environment, taking into account design and manufacturing techniques.	Only experience for MRZ-proofness is mentioned (Standard 1, Section 4.13).
123.	9.2 Experience Data	Experience data: (1) analysis or previous qualification test data (2) documented data from equipment experienced earthquakes (3) data from operating or other dynamic loadings.	No.
124.	9.2.1 Previous Qualifications	By using a combined test and analytical technique (see Section 6, Section 8) on base of clear documentation about previous qualification.	See item 118.
125.	9.2.2 Earth-quakes	By using a documented performance of equipment in facilities subjected to an earthquake on base of extrapolation or interpolation of measurements (see 9.3.1).	No.
126.	9.2.3 Other Experience	By using of documented operating or other dynamic loading (see 9.2.2).	No.
127.	9.3 Similarity	Comparison of (1) excitation (2) physical system (dynamic properties and operability) (3) dynamic response.	See item 118.
128.	9.3.1 Excitation	Similarity of excitation parameters such as spectral characteristics, duration, directions of excitation axes, and location of measurement.	See item 118.
129.	9.3.2 Physical Systems	Similarity of dynamic properties and construction.	See item 118.
130.	9.3.3 Dynamic Response	Similarity of a physical system response (duration, frequency content, amplitude, etc).	See item 118.
131.	9.3.4 Operability	The safety function must be defined for both during and after the earthquake.	See item 118.

3.10. Documentation (Section 10)

Table 11.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
132.	10.1 General	The documentation should include a clear and accurate description of the requirements, analysis and testing method, re-cording of the procedures and results of the test and analysis. Proprietary data should be available for audit and source documents identified and referenced.	No.
133.	10.2 Specification Requirements	Specification information required for either analysis or test: (1) RRS for the mounting surface, including the damping values (2) floor motion (3) operational settings (4) identification of safety-related devices (5) duration (6) number of OBE (7) loadings (8) acceptance criteria (9) special requirements for tests or analyses (10) margins (see 10.2(1) through 10.2(9)) (11) equipment mounting details (12) physical description of equipment (13) deflection requirements (14) environment.	No.
134.	10.3 Seismic Qualification Report	Should include: (1) identification of qualified equipment being should be clearly identified (2) RRS levels (3) detailed summary of the test or analysis procedure, or both, and results (4) conclusions (see 10.3 (1) through 10.3(3)) (5) an approved signature and date. Also documentation on test failures, observed anomalies, equipment refurbishment.	No.
135.	10.3.1 Analytical Data	The method and data (including boundary conditions, input/output data, mathematical model verification testing, interface reaction forces) in a step-by-step form readily auditable by skilled persons. For used computer programs: options, version numbers, dates, and systems, their verification and validation of computer pro-grams on the utilized computer hardware.	No.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
136.	10.3.2 Test Data	Test data should contain (1) for the equipment being qualified – (a) tested equipment identification (b) tested equipment functional specification (c) tested equipment settings and limitations (2) for test facility information – (a) location (b) testing equipment and calibration (3) test method and procedures (4) equipment mounting details (5) test data (6) test results and conclusions.	No.
137.	10.3.3 Combined Methods of Analysis and Testing	If proof of performance is by analysis and testing or by extrapolation from similar equipment, the report should contain (1) reference to used method (2) description of involved equipment (3) analysis data (4) test data (5) justification of results.	No.
138.	10.3.4 Experience Data	Experience data should include equipment supports and interface conditions, safety-function requirements and the experience response data (analysis reports, test-data records, logs of measurements, operating logs and the results of reviews, inspections, or interviews recorded sufficiently soon after an experience event).	No.
139.	10.3.4.1 Excitation	The origin of the experience response spectra (ERS), the fatigue analysis.	No.
140.	10.3.4.2 Physical Systems	Justification of similarity of qualified equipment to data-base equipment together with support and interface conditions.	No.
141.	10.3.4.3 Operability	Documentation of the data-base equipment performance under conditions equal to or more severe than the normal and abnormal levels for the qualified equipment.	No.

3.11. Measurement of ZPA (Informative) (Annex A)

Table 12.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
142.		The ZPA for the TRS is required to en-velop the ZPA of the RRS. The methods for obtaining the ZPA.	No.

3.12. Frequency Content and Stationarity (Informative) (Annex B)

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
143.		Analysis of (1) frequency content and (2) the stationarity of the frequency content for a good simulation of the postulated seismic excitation.	No.

3.13. Fragility Testing (Informative) (Annex C)

Table 13.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
144.		Fragility testing technology and application of results.	No.

3.14. Test Duration and Number of Cycles (Informative) (Annex D)

Table 14.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
145.		The determination of number of test peak beats and cycles.	No.

3.15. Statistically Independent Motions (Informative) (Annex E)

Table 15.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
146.		Verification of statistical independence by the use of the coherence function or by the correlation coefficient function.	No.

4. Conclusion

The following general notes concerning the compared standards can be given:

- The area of IEEE standard is more narrow than Russian standard 1 (NP-031-01);
- The IEEE standard is more technically (physically, methodologically) fundamental, complete and practically useful, e.g. right up to the content of documentation about testing;
- The Russian standard 1 (NP-031-01) is unaccomplished – it uses modern approach with acelerograms and response spectra, but it has no proper methodological support and so on, whereas some aspects are determined unambiguously, e.g. formulas for analytical calculation of exertions, and formally this standard is concerned to new NPPs;
- The Russian standards 2, 3 (GOST 17516.1-90, GOST 16962.2-90) are much more clear and efficient, although their approach does not correspond to modern one, and these standards are applicable on acting NPPs; their requirements are not directly compatible with IEEE standard due to mentioned difference in approach.

Final conclusion concerning mutual certification of the digital I&C systems designed in Korea and Russia can be made as following:

- Generally, the IEEE standard is comprehensive and strict enough as compared with Russian analogous ones, but some difficulties may be encountered due non-completeness of system of Russian standards and differences in approaches between them.

부록 VI

한-러 계측제어 규제요건 검토:

전기기기 내환경 검증 기준

Comparison of the Standards applied to NPP I&C design in Korea and Russia

Comparison of the ANSI/IEEE Std 323-2003

"IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations" (applied in Korea) and Analogues (similar) standards applied in Russia

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Table of Contents

1. Introduction

This section is specifying the standards selected for a comparison: the given IEEE standard and the corresponding standards applied for Russian NPPs, which are selected for comparison, as well as the reasons why they have been selected.

Table 9. List of the standards selected for comparison

IEEE Standard applied in Korea	Standards applied in Russia, selected for a comparison
ANSI/IEEE 323-2003 "IEEE Standard for Qualifying Class 1E[1] Equipment for Nuclear Power generating Stations"	1. GOST 25804.5-83, "Atomic power station technological process control system equipment. General rules of conducting test specimens and serial items test acceptance". 2. GOST 25804.7-83, "Atomic power station technological processes control system equipment. Evaluation methods of meeting durability, endurance id resistance requirements for highest influential factors". 3. GOSATOMNADZOR of Russia, RB-004-98 "Requirements for certification of control system important for safety of nuclear plants"
	Standards applied in Russia, selected for an additional consideration
	4. Federal norms and rules in the area on the use of nuclear energy. NP-026-01, 2001, "The requirements to control system important for safety of nuclear stations" 5. GOST 29075-91, "Nuclear instrumentation systems for nuclear power stations. General requirements"

Standard 1 is selected for comparison because this standard defines the general rules and procedures of testing and acceptance of NPP equipment.

Standard 2 is selected because this standard defines methods for equipment qualification.

Standard 3 provides some additional requirements for testing and qualification as well as the requirements to the testing facility.

Standard 4 provides some additional requirements to be taken into consideration, in particular some definitions and classification principles.

[1] Class 1E: The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment.

Standard 5 provides some requirements for the nuclear instrumentation systems which should be checked during formal testing. In particular, chapter 5 of this standard provides the requirements on durability, stability and endurance against the external affecting factors.

2. Acronyms

The following acronyms are used in this report:

AM	Automation Means
GOST	Russian abbreviation (State Standard)
IEEE	Institute of Electrical and Electronics Engineers
NPP	Nuclear Power Plant
SRCS	Safety Related Control Systems
QA	Quality Assurance

3. Comparison of the standards

3.1 Scope (Section 1)

Table 10. Comparison of Section 1of the IEEE 323-2003

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
	1	The standard describes the basic requirements (principles, methods, and procedures) for qualifying Class 1E equipment. The standard does not provide environmental stress levels and performance requirements.	**Standard 1** provides the general rules and procedures of testing and acceptance (qualifying) of NPP equipment against of the performance requirements established in GOST 25804.2-83, GOST 25804.3-83 and GOST 25804.4-83. **Standard 2** defines the requirements for tests and the assessment methods for equipment qualification while the general rules and procedures are according to the Standard 1. **Standard 3** describes the requirements to certification of the safety related control systems supplied to nuclear plants and certification of the components of such systems; provides some requirements for testing and qualification as well as the requirements to the testing facility.

3.2 References (Section 2)

Table 11. Comparison of Section 2 of the IEEE 323-2003

#	Section number	References of the IEEE 323-2003	References of Russian standards 1 and 2
	2	IEEE Std. 344-1987 (1993) – recommended practice for seismic qualification.	GOST 25804.1-83, GOST 25804.2-83, GOST 25804.3-83, GOST 25804.4-83 – requirements for NPP equipment including the equipment classification and definitions.
		IEEE Std. 603-1998 – standard criteria for safety systems for NPPs. IEEE Std. 7-4.3.2-2003 – standard criteria for digital computers in NPP safety systems.	GOST 20.57.406-81 – methods for testing the electrical equipment.

3.3 Definitions (Section 3)

Table 12. Comparison of Section 3 of the IEEE 323-2003

#	Section number	Main definitions of the IEEE standard	What corresponds in the standards applied in Russia
1	3	The general terminology is according to IEEE-100. Among 19 definitions the most important definitions are:	The general terminology should be taken from GOST 25804.1-83 “Automatic nuclear power station technological processes control system equipment. General provisions”. Terminology which is specific for equipment testing is presented in GOST 16504-81.
1		**Class 1E:** The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing significant release of radioactive material to the environment.	A classification of equipment is presented in GOST 25804.3-3. According to GOST 25804.3-3 the Class 1E equipment corresponds to the Class 2 equipment. The GOST 25804.3-3 also defines 9 subclasses depending of operation conditions (place at NPP). The GOST 25804.3-3 provides a list of external factors and their parameters (around 20) under which the Class 2 equipment must work normally and demonstrate performance requirements.
2		**Equipment qualification:** The generation and maintenance of evidence to ensure that equipment will operate on demand to meet system performance requirements during normal and abnormal service conditions and postulated design basis events.	A term “Equipment qualification” is not presented in the reference standards – it is covered by terms of *assessment*, *examination* (*check up*) and different type of *testing*. The results of tests, properly documented are a basis for *equipment certification*. So this term is also should be taken into consideration.

3.4 Principles of equipment qualification (Section 4)

Table 13. Comparison of Section 4 of the IEEE 323-2003

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
	4.1	Qualification objectives – to demonstrate with reasonable assurance that Class 1E equipment for which a qualified life or condition has been established can perform its safety functions(s).	Standard 1 (item 1.1) – the objectives are to ensure that equipment meets the requirements established by other standards (see reference standards) for the equipment items or system. Standard 3 (item 3.8) - compliance of the parameters and characteristics of the certified SRCS with the established requirements must be verified by analysis of the following: design and operating procedures, results of tests performed at design and production stages; results of certification tests.
2.	4.2	Qualified life and qualified condition – establishing a qualified life and qualified condition for equipment with significant ageing mechanism.	Standard 1 (7.7) does not establish the qualified life and qualified conditions directly – these data are to be taken from the requirements established for different equipment by the specific technical requirements according to GOST 258046-83, GOST 25804.7-83 and GOST 25804.8-83.
3	4.3	Qualification elements – a list of the essential elements of equipment qualification	Standard 1 (item 3.1) – qualification elements are to be established in technical requirements or standards for the particular equipment. Attachment 1 contains a list of essential elements of equipment parameters to be checked before testing.
4	4.4	Qualification documentation	Standard 1 (item 7.12) – documentation according to GOST 15001-73

3.5 Qualification methods (Section 5)

Table 14. Comparison of Section 5 of the IEEE 323-2003

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
1	5.1.1	Type testing – general principal to establish a test program for particular equipment.	Standard 1 (item 2.7) defines 38 types of testing for equipment of 1st category 43 types for equipment of 2nd category and 31 types for equipment of category 3. For qualifying Class 1E equipment the tests for equipment of 2nd category is to be performed and the required equipment performance demonstrated. Standard 2 provides the detailed description of type testing for different equipment working under different conditions – see Attachment 2 for more details. Standard 4 (item 2.19) quality of control system and automatics have to be confirmed by results of implementation of the QA procedures – see attachment 4 for more details. Also item 2.22 require that design documentation for control system must have test program and test procedure.
2	5.1.2	Operating experience – performance data from equipment of similar design that has successfully operated under known service conditions may be used in qualifying other equipment to equal or less severe conditions.	Standard 1 (item 7.4) – use of performance data obtained from equipment of similar design that has operated under known conditions may be used in qualifying process with an agreement of customer (end-user). Standard 3 (item 3.12) - the system software of the SRCS must have a history of wide commercial application in the industry.

3	5.1.3	Analysis – qualification may be supported by analysis, however analysis alone cannot be used to demonstrate qualification.	Standard 1 (item 1.2) – Analytical methods are to be used for qualification in a combination with other methods. Standard 2 (item 4.1.2 – 4.1.3) - the rules to use analytical methods, mainly as a basis before testing and qualification.
4	5.1.4	Combined methods – equipment may be qualified by combinations of type test, operating experience, and analysis.	Standard 1 (item 1.2) – With an agreement of customer (end-user) qualification of equipment should be performed by analytical methods, type test or their combination. This should be established and stated in technical requirements or standards for the particular equipment.
5	5.2	Extension of qualified life – general approach and methods for extension of the qualified life.	Standard 1 (item 3.2) provides requirements for periodic testing which could be used for an extension of qualified life. But the standard 1 does not use this approach for extension of qualified life specifically.
6	5.3	Condition monitoring – may be used in place of a qualified life to determine if qualified equipment is suitable for further service.	Standard 1 does not mentioned the condition monitoring, the other standards as well.

3.6 Qualification program (Section 6)

Table 15. Comparison of Section 6 of the IEEE 323-2003

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
1	6.1	Equipment specification – essential information about equipment to be qualified	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment
2.	6.1.1	Identification	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment
3	6.1.2	Interfaces	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment
4	6.1.3	Qualified life objective	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment
5	6.1.4	Safety function(s)	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment
6	6.1.5	Service conditions	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment Standard 5 (Chapter 5) - provides the requirements on durability, stability and endurance against the external affecting factors for different NPP locations (zones).
7	6.1.5.1	Normal and abnormal service conditions	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment
8	6.1.5.2	Design basis event conditions	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment
9	6.1.5.3	Margin	Standard 1 (item 6.1) – according to the technical requirements for the particular equipment

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
10	6.2	Qualification program plan shall define tests, inspections, performance evaluation, acceptance criteria, and required analysis to demonstrate that equipment can perform its specified safety functions.	Standard 1 (section 6) provides the detailed information on planning the type test but not qualification program plan (in fact only part of qualification program is covered).
11	6.2.1	Ageing	Standard 1 – not specifically addressed, to be specified in the technical requirements for the particular equipment
12	6.2.1.1	Significant ageing mechanisms	Standard 1 – not specifically addressed, to be specified in the technical requirements for the particular equipment
13	6.2.1.2	Ageing considerations	Standard 1 – not specifically addressed, to be specified in the technical requirements for the particular equipment
14	6.2.2	Qualified life objective	Standard 1 – not specifically addressed, to be specified in the technical requirements for the particular equipment
15	6.2.3	Margin	Standard 1 – not specifically addressed, to be specified in the technical requirements for the particular equipment
16	6.2.4	Maintenance	Standard 1 – not specifically addressed, to be specified in the technical requirements for the particular equipment
17	6.2.5	Acceptance criteria	Standard 1 – not specifically addressed, to be specified in the technical requirements for the particular equipment
18	6.3	Qualification program implementation	Standard 1 (item 7.10) – GOST 15.001-73 are to be used.
19	6.3.1	Type testing	Standard 1 (item 2.7) defines different types of testing for equipment of categories 1, 2 and 3. For qualifying Class 1E equipment the tests for equipment of 2nd category is to be performed and the required equipment performance demonstrated.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
20	6.3.1.1	Test plan – the elements of test plan	Standard 1 (item 3.2) – test plan is to be established and specified in the technical requirements for the particular equipment. Item 3.3 also requires establishing test plan with an agreement of the customer (end-user).
21	6.3.1.2	Simulated test profiles – the user shall furnish sufficient environmental data to allow the simulation of the design basis event environmental qualification profile for the equipment being qualified.	Standard 1 – these data are to be specified in the technical requirements for the particular equipment. The standard environmental conditions if other are not specified in the equipment technical specification are to be taken from items 4.1, 4, 2 and 4.3. Also the following standards are to be used when applicable: GOST 25804.7-83, GOST15150-69, GOST 25804.6-83 and GOST 25804.8-83. Standard 3 (item 3.9) - certification tests of SRCS, their AM and components must be conducted under the conditions close to the conditions of operation at NPP to which the equipment is supplied, with the due consideration of the requirements of applicable regulatory documents. Standard 5 provides the requirement to this conditions for different NPP locations (zones) under normal operation establishing the values for the temperature (for example from +5C to +50C for one location, from +10C to +40C for the second and +(20±5)C for the third), for humidity, atmospheric pressure and others.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
22	6.3.1.3	Mounting – equipment shall be mounted in a manner and a position that simulates its expected installation.	Standard 1 – these data are to be specified in the technical requirements for the particular equipment. Item 7.1 also requires that a proper mounting is to be established. Item 7.5 requires that equipment shall be mounted in a manner and a position that simulates its expected installation in the extent possible. Standard 2 (item 1.1.2) – the same. Items 1.1.3 - 1.1.8 provide more details on mounting for different equipment.
23	6.3.1.4	Connections – that equipment shall be connected in a manner that simulates its expected installation.	Standard 1 – these data are to be specified in the technical requirements for the particular equipment. Item 7.2 requires that equipment shall be connected and loaded in a manner that simulates its expected installation.
24	6.3.1.5	Monitoring – the general requirements to monitoring and measurements	Standard 1 (item 5.2) the monitoring and measurement equipment shall provide the necessary accuracy and resolution. Measurement data accuracy shall correspond the requirements of the state measurement system. Standard 2 (item 4.2.9) - Measurement data accuracy shall correspond the requirements of the GOST 25804.2-83. Item 4.2.10 provides margins for measurements of ionizing radiation. Standard 3 (3.17) - the test laboratory performing the certification tests of the SRCS and its components must be accredited according to the relevant industry rules and comply with the requirements of the section 6 of the guideline – see Attachment 3 for more details. The same for automatics (item 4.13).

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
25	6.3.1.6	Margin – the suggested margins are presented. Peak temperature: +8C Peak pressure: ±10% of gauge Radiation: +10% (on accident dose) Power supply voltage: ±10%	Standard 1 – these data are to be specified in the technical requirements for the particular equipment. Standard 2 (item 1.1.1) provides 16 margins for tests during mechanical disturbances and factors, in particular: Peak temperature: +2C Peak pressure:+10^{-2} MPA Radiation: ±20% Power supply voltage: not observed
25	6.3.1.7	Test sequence – the specific requirements for test sequence	Standard 1(item 3.2) – the test sequence shall be specified in the technical requirements for the particular equipment and to be organized according to the table 2. Item 3.2 also provides a list of test that may be not included in the periodical testing. Standard 2 requires that mechanical test shall be performed after the tests under ionizing radiation.
26	6.3.1.8	Ageing	Standard 1 – ageing significance is not specifically mentioned, it is to be specified in the technical requirements for the particular equipment.
27	6.3.1.8.1	Natural ageing – use of a naturally aged test sample for type testing	Standard 1 (item 7.4) – use of performance data including ageing data obtained from equipment of similar design that has operated under known conditions may be used in testing process with an agreement of customer (end-user).
28	6.3.1.8.2	Age conditioning -	Standard 1 – age conditioning is not mentioned.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
29	6.3.1.9	Radiation – a simulation the effects of the radiation exposure.	Standard 1 (Table 2) – two tests are to be performed to simulate the effects of radiation exposure and neutron flux. After the radiation test additional test shall be performed according to GOST 25804.6-83 (item 2.4).
30	6.3.1.10	Seismic and nonseismic vibration – requirements to vibration tests, seismic events according to IEEE Std 344-1987.	Standard 1 (Table 2) – the special tests are to be performed. The seismic testing is a subject of the standard NP-031-01. Standard 2, items 1.2 – 1.10 provide the detailed description of vibration and single influence tests and assessment criteria.
31	6.3.1.11	Operation under normal and design basis event conditions – it shall be demonstrated that equipment can adequately perform its safety functions under the identified service conditions.	Standard 1 (Table 2) – all necessary tests are to be performed, also according to the tests specified in the technical requirements for the particular equipment. Standard 2 - according to the tests specified in the technical requirements for the particular equipment and under the identified service and standard 2 conditions. Standard 3 (item 3.10) - the parameters to be tested during certification tests of the SRCS, and their components must include the safety related parameters characterizing the SRCS as a part of the NPP technological process, presented by software, and as a part of the NPP equipment, presented by the hardware.

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
32	6.3.1.12	Inspection – visual inspection	Standard 1 (Attachment 1, item 1) – visual inspection is to be performed. Standard 2 (item 1.1.4) – visual inspection is to be performed before testing as well as a measurement of equipment parameters. A list of parameters is to be provided in the technical requirements for the particular equipment.
33	6.3.2	Operating experience – Portion or all of an equipment qualification program may be satisfied by documented operating experience.	Standard 1 (item 7.4) – use of performance data obtained from equipment of similar design that has operated under known conditions may be used in qualifying process with an agreement of customer (end-user). Standard 3 (item 3.12) - the system software of the SRCS must have a history of wide commercial application in the industry. Item 4.7 - The system software of the AM must have a history of wide commercial application in the industry.
34	6.3.2.1	Operating history	Standards 1 and 3 – as above
35	6.3.2.2	Determination of qualification	Standard 1 – as above
36	6.3.3	Analysis – requirements for qualification by analysis	Standard 1 (item 1.2) – Analytical methods are to be used for qualification in a combination with other methods. Standard 3 (item 3.15) - methods of reliability analysis used during certification must be attested. Item 4.10 – the same for AM.
37	6.3.4	Extrapolation and interpolation – a possibility to use two types of extrapolation and interpolation to qualify equipment	Standard 1 – a subject is not observed.
38	6.3.4.1	Material	
39	6.3.4.2	Size	

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
40	6.3.4.3	Shape	
41	6.3.4.4	Stress	
42	6.3.4.5	Ageing mechanisms	
43	6.3.4.6	Function	
44	6.3.5	Extension of qualified life – the ways to extend the qualified life.	Standard 1 (item 3.2) provides requirements for periodic testing which could be used for an extension of qualified life. But the standard 1 does not use this approach for extension of qualified life specifically.
45	6.3.6	Condition-based qualification – the general recommendations and conditions for condition-based qualification.	Standard 1 – a subject is not observed.
46	6.3.7	Acceptance criteria.	Standard 1 – the acceptance criteria are to be specified in the technical requirements for the particular equipment and demonstrated during testing. Also item 7.11 require that acceptance shall be done according to GOST 25804.6-83, GOST 25804.7-83 and GOST25804.8-83. Standard 2 (item 1.1.7 – 1.119) provide the acceptance criteria for tests during mechanical disturbances and factors.
47	6.4	Modifications – modifications to the equipment or to the qualification basis made during or after completion of the qualification program shall be evaluated to determine whether additional qualification steps are required.	Standard 1 (item 3.3) – The equipment modifications shall be taken into consideration when the type of tests and their sequence are to be established on the basis of Table 2. It should be done with an agreement of the customer (end-user).

3.7 Documentation (Section 7)

Table 16. Comparison of Section 7 of the IEEE 323-2003

#	Section number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds in the standards applied in Russia
1	7.1	Mild environment documentation.	Standard 1 (item 7.12) – documentation according to GOST 15001-73.
2	7.2	Harsh environment documentation.	Standard 1 (item 7.12) – documentation according to GOST 15001-73.

4. Conclusion

The ANSI/IEEE 323-2003 “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power generating Stations” describes the basic requirements (principles, methods, and procedures) for qualifying Class 1E equipment. For the purpose of the entire comparison three Russian standards have been selected:

- GOST 25804.5-83, “Atomic power station technological process control system equipment. General rules of conducting test specimens and serial items test acceptance” because this standard defines the general rules and procedures of testing and acceptance of NPP equipment.
- GOST 25804.7-83, “Atomic power station technological processes control system equipment. Evaluation methods of meeting durability, endurance id resistance requirements for highest influential factors” because this standard defines methods for equipment qualification, and
- GOSATOMNADZOR of Russia, RB-004-98 “Requirements for certification of control system important for safety of nuclear plants” as it provides some additional requirements for testing and qualification as well as the requirements to the testing facility.

Some additional information has been taken from the regulatory documents:

- Federal norms and rules in the area on the use of nuclear energy. NP-026-01, 2001, “The requirements to control system important for safety of nuclear stations”
- GOST 29075-91, “Nuclear instrumentation systems for nuclear power stations. General requirements”

On the basis of the completed comparison presented above the following conclusions can be made:

- While the ANSI/IEEE 323-2003 standard provides the basic requirements for equipment qualification the Russian standards provide more requirements and technical data on specific conditions and regimes to be checked and assessed. In this respect the Russian standards are stricter. From other point, methodological approach of the ANSI/IEEE 323-2003 is more comprehensive and provide modern approach to equipment qualification in a comparison with the Russian standards issued more then 20 years ago.
- For the purpose of mutual certification of the digital I&C equipment designed in Korea and Russia the document RB-004-98 “Requirements for certification of control system important for safety of nuclear plants” is essential. In particular the document defines that (item 3.6) - the procedures for recognition of the certificates issued for SRCS or their component and AM for NPN must be based on the analysis of compliance with the requirements to the systems and components existing in the country of production and the requirements, prescribed for such equipment within Russia; (item 3.7) - in the purchasing agreement (contract) for the purchase of SRCS, their AM and components imported for a NPP, funding must be allocated for the process of compulsory certification or the procedure of recognition of foreign certificates within the existing certification system.
- The detailed comparison of certification procedures for digital I&C equipment is recommended as well as pilot certification of a selected system or device.

Attachment 1. Short description of GOST 25804.5-83, “Atomic power station technological process control system equipment. General rules of conducting test specimens and serial items test acceptance” (Referenced as Standard 1 in this document)

This standard (GOST 25804.5-83) provides the general rules and procedures of testing and acceptance (qualifying) of NPP equipment against of the performance requirements established in GOST 25804.2-83, GOST 25804.3-83 and GOST 25804.4-83.

Section 1 provides the general provisions.

Section 2 provides the requirements for testing of the model equipment. Type tests and their sequence are presented. Depending of equipment some test are obligatory, some to be defined by the technical requirements on entire equipment.

Section 3 provides the requirements for testing of the industrial equipment.

Section 4 provides the general requirements for testing and assessment. References are made to GOST 25804.7-83, GOST 15150-69, GOST 25804.6-83, GOST 25804.7-83, GOST25804.8-83

Section 5 provides the general requirements for the technical means are used for equipment testing including the requirements for metrological support. The technical means are to be used for equipment testing shall provide the type testing as required in GOST 25804.3-83, GOST 25804.6-83, GOST 25804.7-83, GOST 25804.8-83.

Section 6 provides requirements for test planning and preparation activities. These activities shall define tests, inspections, performance evaluation, acceptance criteria and analysis to demonstrate that the equipment can perform its specified functions according to the appropriate technical requirements for the entire equipment.

Section 7 provides requirements for test implementation and acceptance. The tested equipment shall demonstrate compliance with the technical requirements established for the entire equipment in GOST 25804.3-83, GOST 25804.6-83, GOST 25804.7-83, GOST 25804.8-83 and other applicable standards and norms.

Attachment 1 (recommended) - A list of characteristics and parameters to check during qualification of industrial equipment.

Attachment 2 (recommended) – A list of characteristic and parameters to check during periodical testing of industrial equipment.

Attachment 2. Short description of GOST 25804.7-83, "Atomic power station technological processes control system equipment. Evaluation methods of meeting durability, endurance id resistance requirements for highest influential factors" (Referenced as Standard 2 in this document)

This Standard (GOST 25804.7-83) defines the requirements for tests and the assessment methods for equipment qualification while the general rules and procedures are according to the Standard GOST 25804.3-83. The standard GOST 20.57.406-81 provides methods for testing the electrical equipment.

Section 1 provides the test methods for assessment of equipment in meeting system performance requirements on durability and steadiness (stability) during mechanical disturbances and factors. The requirements for the following items are presented – test plan, simulated test profiles, mounting, connections, margins, test sequence, acceptance criteria.

Section 2 has similar structure and provides the test methods for assessment of equipment in meeting system performance requirements on durability and steadiness (stability) under climatic factors, mustiness and impermeability.

Section 3 provides the test methods for assessment of equipment in meeting system performance requirements on durability during an influence of the special (medium) factors, one- or multi-component medium.

Section 4 provides the test methods for assessment of equipment in meeting system performance requirements on durability during an influence of ionizing radiation as well as the test methods for assessment of equipment in meeting system performance requirements on durability and steadiness (stability) during an influence of electromagnetic fields.

Section 5 provides a reference to industrial safety standard GOST 1.26-77. The requirements of this standard should be met during the implementation of test program.

Attachment 3. Short description of safety Guide RB-004-98 "Requirements for certification of control system important for safety of nuclear plants" issued by the GOSATOMNADZOR of Russia (Referenced as Standard 3 in this document)

The guide describes general concepts related to the implementation of the Federal law on the use of the nuclear power, requirements to certification of the safety related control systems supplied to nuclear plants and certification of the components of such systems, including: control hardware systems and software hardware modules, automated systems and complexes and software, including the imported software and hardware intended to perform safety related functions. In the text of the Guideline references are provided to regulatory documentation requirements of which must be considered in the process of certification of the safety related control systems, their components as well as automated modules and software associated with them.

Chapter 3 provides the requirements to certification of safety related control systems of nuclear plants and components of the systems. In particular for the purpose of the present comparison the following statements are important:

3.8. Compliance of the parameters and characteristics of the certified SRCS, their AM and components for NPP with the existing requirements must be verified by means of analysis of the following:

- design and operating documentation
- results of tests performed at design and production stages;
- results of certification tests.

3.9. Certification tests of SRCS, their AM and components must be conducted under the conditions close to the conditions of operation at NPP to which the equipment is supplied, with the due consideration of the requirements of applicable regulatory documents.

3.10. The parameters to be tested during certification of the SRCS, and their components must include the safety related parameters characterizing the SRCS as a part of the NPP technological process, presented by software, and as a part of the NPP equipment, presented by the hardware.

3.11. It is recommended to consider during certification of the SRCS two of its constituents - the system software needed for running the applications and the applications themselves. The documents justifying the following safety related parameters should be taken into account:

1) justification of reliable performance of each safety related function;

2) reports containing analysis of hazardous responses of the system to external

events and component failures

3) documents containing information about compliance with the main safety

principles, including:

- single failure
- diversity
- segregation
- redundancy

3.12. The system software of the SRCS must have a history of wide commercial application in the industry.

3.13. The recommended procedures for the SRCS certification are to be presented in the industry requirements.

3.14. It is recommended to attach plant specific information to the SRCS or its component compliance certificate.

3.15. The methods of reliability analysis used during certification must be attested.

3.16. It is recommended to use in the SRCS the AM having the certificates of compliance with the requirements presented in the paragraph 3.2 of the present guideline.

3.17. The test laboratory performing the certification tests of the SRCS and its components must be accredited according to the relevant industry rules and comply with the requirements of the section 6 of the guideline.

Chapter 4 provides the requirements to certification of automatics. In particular:

4.4. The certification tests must be conducted in the conditions close to the actual operating and environmental conditions of the SCRS.

4.5. The parameters to be tested during certification of the AM must include the safety related parameters characterizing the AM as a part of the NPP technological process, presented by software, and as a part of NPP equipment, presented by the hardware.

4.6. It is recommended to consider during the obligatory certification of the AM two of its software constituents - the system software needed for running the applications and the applications themselves. The documents justifying the following safety related parameters should be taken into account:

1) justification of reliable function performance;

2) reports containing analysis of hazardous responses of the AM to external events and component failures

3) documents containing information about automated continuous diagnostics and random checks by operators.

4.7. The system software of the AM must have a history of wide commercial application in the industry.

4.8. The recommended procedures for the AM certification are to be presented in the industry requirements.

4.9. It is recommended to attach to the AM compliance certificate the information about the SRCS for which the automatics is recommended.

4.10. The methods of reliability analysis used during certification must be attested.

4.11. Certification of the software must be performed in correlation with the hardware It can be performed in an independent manner if the software and the hardware is produced and supplied to the NPP by different companies.

The testing laboratory performing the certification tests of the AM and its components must be accredited according to the relevant industry rules and comply with the requirements as below **Chapter 6** of the entire document):

6.1. The activities of the testing laboratory aimed at certification testing of SRCS, AM and their components must comply with the requirements of applicable regulations and the Guideline

6.2. The testing laboratory for certification testing of SRCS, AM and their components must be equipped with appropriate instrumentation.

6.3. The instrumentation for the testing laboratory must include the equipment imitating the following:

- location identical to that in the location of the SRCS at the NPP;
- environmental conditions;
- electromagnetic parameters;
- external impacts that can be caused by the failures and design basis accidents accounted for in the NPP design;
- input signals.

6.4. The equipment of the testing laboratory, designed for testing of the SRCS, AM and their components must have a metrological certification.

6.5. The stuff of the testing laboratory must be licensed.

Attachment 4. Short description of the document - Federal norms and rules in the area of the use of nuclear energy. NP-026-01, 2001, “The requirements to control system important for safety of nuclear stations” (Referenced as Standard 4 in this document)

The document has 4 main chapters and 2 attachments: Chapter 1 – purpose of the document and applicability, Chapter 2 – General provisions, Chapter 3 – Control system of normal operation important for NPP safety, Chapter 4 –Control safety systems, Attachment 1 – Correspondence of characteristics of the control system to the functional groups, and Attachment 2 – List of the main quality assurance (QA) procedures for control systems and automatics. In particular, the following QA procedures are to be in place:

1. Factory tests
2. Technological run-through and check up of the functions, specified in the design documentation.
3. Acceptance tests
4. Certification
5. Site tests
6. Quality confirmation during operation
    a. Conformity to the design
    b. Periodic electromagnetic compatibility tests during operation
    c. Metrological tests
    d. Periodical confirmation of reliability by statistical methods.

부록 VII

한-러 계측제어 규제요건 검토 :

소프트웨어 확인 및 검증 기준

Comparison of the Standards applied to NPP I&C design in Korea and Russia

Comparison of the IEEE 1012-1998

"IEEE Standard for Software Verification and Validation"

(applied in Korea)

and

Analogues (similar) standards applied in Russia

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Table of Contents

1. Introduction

The main objective of this paper is to compare requirements for software verification and validation (V&V) stated in the IEEE Std 1012-1998 (applied in many countries including Republic of Korea) with the Russian analogues.

The selected IEEE standard is well-structured document, which describes software verification and validation processes to determine whether development products of given activity conform to the requirements of that activity, and whether the software satisfies its intended use and user needs. This V&V standard addresses all software life cycle processes, including acquisition, supply, development, operation, and maintenance.

The national system of standardization of Russia on normative base capacity does not concede to similar systems of the industrial developed countries (more than 50 thousand normative documents totally), but many normative documents have essential lacks, which make their profit more than doubtful. In other words, sometimes quality of the normative documents is more important rather their quantity.

In Russia there are over 30 state standards in the field of software engineering. But most of these standards are not harmonized with corresponding international standards and not coordinated among themselves. For example, let's consider software quality standards. The state standard GOST 28195-89 ("Quality control of software systems. General principles") offers one approach to control the software quality characteristics, GOST 28806-90 ("Software quality. Terms and definitions") – another, GOST R ISO/IEC 9126-93 ("Software product evaluation. Quality characteristics and guidelines for their use") – third. All of them have become outdated and are not harmonized with new group of ISO/IEC 9126-1, 2, 3, 4 standards.

There are also problems during implementation of the international standards as authentic texts in Russian ones because of significant number of cases of distortion of sense of translated documents. For example, there is no even uniform translation of the term "validation" in Russian standards, which contain the authentic text from corresponding international standards. The standard GOST R ISO/IEC 12207-99 translates this term as "attestation", while the standard GOST R ISO 9000-2001 leaves the term as it is (but in Russian transcription, of course).

Unfortunately, the conducted research has shown that there is no close analogue to IEEE Std 1012-1998 among the Russian standards, there is no such standard, which is fully focused on the same topic (has the same scope or purpose) and developed based on similar systematic approach.

However, there are several documents applied in Russia (partially overlapping each other), which cover some aspects of the same topic as IEEE Std 1012-1998. They have been considered during this comparison and listed in the Table 1.

It seems that the standard GOST R ISO/IEC 12207-99 "Information technology. Software life cycle processes" (which contains authentic text of international standard ISO/IEC 12207-95) is the most closely related to IEEE Std 1012-1998, although standard ISO/IEC 12207 is the standard of much higher level. This standard describes the major component processes of a complete software life cycle and the high-level relations that govern their interactions. This standard covers the life cycle of software from conceptualization of ideas through retirement. The ISO/IEC 12207 describes the following life-cycle processes:

- Primary Processes: Acquisition, Supply, Development, Operation, and Maintenance.

- Supporting Processes: Documentation, Configuration Management, Quality Assurance, **Verification, Validation**, Joint Review, Audit, and Problem Resolution.
- Organization Processes: Management, Infrastructure, Improvement, and Training.

The ISO/IEC 12207 also describes how to tailor the standard for a project.

However, finally the GOST R ISO/IEC 12207-99 was excluded from a comparison because the IEEE Std 1012-1998 (Annex A) has mapping of all ISO/IEC 12207 V&V requirements to the V&V activities and tasks of the IEEE Std 1012-1998.

Table 1. List of the standards selected for comparison.

IEEE Standard applied in Korea	Standards applied in Russia, selected for comparison
IEEE Std 1012-1998 “IEEE Standard for Software Verification and Validation”	1. IEC 60880-1986 “Software for Computers in the Safety Systems of Nuclear Power Stations” *Additional standard used for some definitions clarification:* 2. RD-03-34-2000 Gosatomnadzor of Russia regulatory document – “Requirements to the scope and content of verification and justification report of software used for safety justification of objects of atomic energy use” 3. GOST R ISO 9000-2001 “Quality management systems. Fundamentals and vocabulary” 4. GOST R ISO 9001-2001 “Quality management systems. Requirements” *Relevant standard excluded from comparison due to a cross-mapping made in the IEEE Std 1012:* 5. GOST R ISO/IEC 12207-99 “Information technology. Software life cycle processes”

Standard 1 is old (1986), application-specific, safety related standard that has a guidelines annex on software testing. The standard aimed at very high integrity systems. The standard is selected for comparison because it gives special recommendations for a general approach to software verification and computer system validation. This standard is pointed in the list of the normative documents because it is being taken into account during a certification of the safety significant control systems (Safety Guide RB-004-98 “The requirements for certification of the NPP safety significant control systems”. Gosatomnadzor of Russia, Moscow 1998).

Standard 2 is an additional standard selected for comparison because it contains some definitions clarification and the requirements to the scope and content of verification and justification report on software used for safety justification of objects of atomic energy use.

Standards 3 and 4 are additional standards used for some definitions clarification. The standards contain authentic text from corresponding international standards ISO 9000-2000 and ISO 9001-2000 and state some terms and requirements applicable to the current comparison from quality management point of view.

More details on the contents of standards 2-4 are available in the Attachment.

2. Acronyms

The following acronyms are used in this report:

GOST Russian abbreviation (State Standard)
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronics Engineers
ISO International Organization for Standardization
NPP Nuclear power plant
V&V Verification and Validation

3. Comparison of the standards

3.1 Overview (Clause 1)

Table 2 Comparison of Clause 1 of the IEEE Std 1012-1998

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
1.	**Overview** The standard describes software V&V processes to determine whether development products of given activity conform to the requirements of that activity, and whether the software satisfies its intended use and user needs. The standard implements the V&V framework using the terminology of process, activity and task.	**Standard 1** (Introduction) gives special recommendations for a general approach to software verification and computer system validation. The standard uses such terms like process and activity but has no such clear structure. **Standard 2** (General provisions) contains the requirements to the scope and content of verification and justification report of software used for safety justification of objects of atomic energy use. **Standard 3** (Section 0.1) describes fundamentals of quality management system and specifies the terminology for quality management system. **Standard 4** (Section 1) specifies requirements for quality management system. **Standards 3 and 4** use the system (process) approach with inputs and outputs are similar to the IEEE Std 1012-1998
1.1	**Purpose**	No such topic

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
1.2	**Field of application** The standard applies to software being developed, maintained, and reused.	**Standard 1** (Section 1) is applicable to highly reliable software required for computers to be used in safety systems of NPPs to perform safety functions. **Standard 2** (Section 1.2) – for software used for safety justification of objects of atomic energy use (neutron calculations, heat transfer and hydrodynamic calculations, radiation protection calculations and so on). **Standard 4** (Section 1.2) All requirements of the standard are generic and are intended to be applicable to all organizations, regardless of type, size and product provided.
1.3	**V&V objectives**	No such topic
1.4	**Organization of the standard**	No such topic
1.5	**Audience** The audience for the standard is software suppliers, acquirers, developers, maintainers, V&V practitioners, operators, and managers in both the supplier and acquirer organizations.	**Standard 1** N/A **Standard 2** (Section 1.5) Developers and users of the software, which is subject to certification. This software includes the software for designing, manufacturing, operation and safety justification of objects (and/or their elements) of atomic energy use. **Standards 3 and 4** The audience for these standards is any organization that needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements and aims to enhance a customer satisfaction.

3.2 Normative references (Clause 2)

The IEEE Std 1012-1998 does not require the use of any normative references. Other standards considered to be useful in the implementation and interpretation of this standard are listed in its Annex H.

3.3 Definitions, abbreviations, and conventions (Clause 3)

Table 3 Comparison of the IEEE Std 1012-1998 Clause 3

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
3.1.1	**Acceptance testing**	No such definition in selected standards
3.1.2	**Anomaly** (definition from IEEE Std 1044)	No such definition in selected standards
3.1.3	**Component testing**	No such definition in selected standards
3.1.4	**Criticality**	No such definition in selected standards
3.1.5	**Criticality analysis**	No such definition in selected standards
3.1.6	**Hazard** (definition from IEC 60300-3-9)	No such definition in selected standards
3.1.7	**Hazard analysis**	No such definition in selected standards
3.1.8	**Hazard identification** (definition from IEC 60300-3-9)	No such definition in selected standards
3.1.9	**Independent verification and validation (IV&V)**	No such definition in selected standards though **Standard 1** (6.2.1) mentions independent verification
3.1.10	**Integration testing**	**Standard 1** (Section 2.12) defines the term **integration tests** as tests performed during the hardware/software integration process prior to computer system validation to verify compatibility of the software and the computer system hardware
3.1.11	**Integrity level** (definition from ISO/IEC 15026)	No such definition in selected standards
3.1.12	**Interface design document (IDD)**	No such definition in selected standards
3.1.13	**Interface requirement specification (IRS)**	No such definition in selected standards
3.1.14	**Life cycle process**	There is no exactly the same definition in selected standards, but **Standard 1** (Section 2.17) defines the term **Software life cycle** as the period of time that starts when a software product is conceived and ends when the product is no longer available for use
3.1.15	**Minimum tasks**	No such definition in selected standards
3.1.16	**Optional tasks**	No such definition in selected standards
3.1.17	**Required inputs**	**Standards 3 and 4** use term **inputs** but without definition
3.1.18	**Required outputs**	**Standards 3 and 4** use term **outputs** but without definition
3.1.19	**Risk** (definition from IEC 60300-3-9)	No such definition in selected standards
3.1.20	**Risk analysis** (definition from IEC 60300-3-9)	No such definition in selected standards, but **Standard 1** mentions **risk consideration** as aspect of minor importance to software design

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
3.1.21	**Software design description (SDD)**	No such definition in selected standards
3.1.22	**Software integrity levels** (definition from ISO/IEC 15026)	No such definition in selected standards
3.1.23	**Software requirements specification (SRS)**	**Standard 1** (Section 4) has no such definition but states that **software requirements** shall be derived from requirements of the safety systems and are part of the computer system specification. Details of the software requirements are given in Appendix A2.
3.1.24	**Software verification and validation plan (SVVP)**	There is no exactly the same definition in selected standards, but **Standard 1** uses the term **Verification plan** in section 6.2.1
3.1.25	**Software verification and validation report (SVVR)**	No such definition in selected standards
3.1.26	**System testing**	There is no exactly the same definition in selected standards, but **Standard 2** (Annex 1) defines the term **Test** as a problem, solution of which is known and the term **Testing** as software checking by calculation of problems which solutions are known **Standard 3** (Section 3.8.3) defines the term **Test** as determination of one or more characteristics according to a procedure
3.1.27	**Test case**	No such definition in selected standards
3.1.28	**Test design**	No such definition in selected standards
3.1.29	**Test plan**	No such definition in selected standards
3.1.30	**Test procedure**	No such definition in selected standards
3.1.31	**Validation** (definition from ISO 8402:1994) Conformation by examination and provisions of objective evidence that the particular requirements for a specific intended use are fulfilled	**Standard 1** (Section 2.20) defines **Validation** as the test and evaluation of the integrated computer system (hardware and software) to ensure compliance with the functional, performance and interface requirements **Standard 2** (Annex 1) states the term, which can be translated in English as **software attestation** or **software validation** and defines it as regulated procedure of acceptance of possibility of software usage in stated areas/boundaries of application, which is completed by issuance of the certificate **Standard 3** (Section 3.8.5) gives similar to IEEE Std 1012-1998 definition.

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
3.1.32	**Verification** (definition from ISO 8402:1994) Confirmation by examination and provisions of objective evidence that specified requirements have been fulfilled	**Standard 1** (Section 2.21) defines **Verification** as the process of determining whether or not the product of each phase of the digital computer system development process fulfils all the requirements imposed by the previous phase **Standard 2** (Annex 1) defines **Software Verification** as justification of possibility of software usage in stated field of application and justification of the inaccuracies made in parameters calculations by comparison with experimental data, calculated data obtained with the help of other software, outcomes of analytical tests, the theoretical analysis **Standard 3** (Section 3.8.4) gives similar to IEEE Std 1012-1998 definition

3.4 V&V software integrity levels

Software criticality is a description of the intended use and application of a system. The IEEE Std 1012-1998 uses a software integrity level approach to quantify software criticality. Software integrity levels denote a range of software criticality values necessary to maintain risks within acceptable limits.

Neither of considered standards uses this approach. But it's possible to note that field of application of **Standard 1** and **Standard 2** (safety related software) corresponds to the highest software integrity level 4 (Criticality is High) of the IEEE Std 1012-1998.

3.5 V&V processes

Table 4 Comparison of the IEEE Std 1012-1998 Clause 5

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
5	The standard addresses all software life cycle processes defined by industry standards. V&V processes support the management, acquisition, supply, development, operation and maintenance processes. The standard defines minimum V&V activities and tasks supporting the above processes. In this standard, V&V processes are discussed together because the V&V activities and tasks are interrelated and complementary. But it's noted that in some circumstances, the verification process may be viewed as a process separated from validation process.	**Standard 1** uses other life cycle model. The body and the appendices of the standard are not consistent in definition of the life cycle phases. These phases correspond to some processes and activities defined in the IEEE Std 1012-1998. In this standard the processes of verification and validation are discussed separately (software verification and system validation). Section 6 defines verification processes for **requirements**, **design** and **coding (implementation)** phases of the life cycle. These phases correspond to some activities (Requirements V&V, Design V&V and Implementation V&V activities) of the development process defined in the IEEE Std 1012-1998. Section 7.5 defines **Integrated system verification**. Section 8 defines **Computer system validation**. The standard (Section 6) states that software verification ends each lifecycle phase, but the wording is not sufficiently strong.
5.1	**Process: Management**	No such definition in selected standards
5.2	**Process: Acquisition**	No such definition in selected standards
5.3	**Process: Supply**	No such definition in selected standards
5.4	**Process: Development**	**Standard 1** does not define **development** phase, but it is mentioned in Appendix B that development consists of design and coding **Standard 4** (Section 7.3.5) states that **verification** shall be performed in accordance with planned arrangements to ensure that the design and developments outputs have met the design and development input requirements. Section 7.3.6 of the Standard states that design and development **validation** shall be performed in accordance with planned arrangements to ensure that the resulting product is capable to meet the requirements for the specific application or intended use, where known. The standard also states (Section 7.3.7) that design and development changes shall be reviewed, verified and validated, as appropriate, and approved before an implementation.

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
5.4.1	**Activity: Concept V&V**	No such definition in selected standards
5.4.2	**Activity: Requirements V&V** This activity addresses software requirements analysis. The objectives of V&V are to ensure the correctness, completeness, accuracy, testability, and consistency of the requirements.	**Standard 1** (Section 6.1) states that after the software functional requirements have been established and before the next phase begins, verification addresses the adequacy of the software functional requirements in fulfilling the safety system requirements assigned to the software by the computer system specification. Adequacy is not defined in the standard. The standard does not contain defined activities and tasks to be performed for requirements V&V.
5.4.3	**Activity: Design V&V** This activity addresses software architectural design and software detailed design. The objectives of V&V are to demonstrate that the design is correct, accurate, and complete transformation of the software requirements and that no unintended features are introduced.	**Standard 1** (Section 6.1) states that after the design phase and before the next phase begins, verification addresses the adequacy of computer system software design as documented in the software performance specification to the software functional requirements. Section 6.2.2 (subsection on section 6.2 which defines software verification activities) also defines that design verification addresses: a) the adequacy of the software performance specification for the software functional requirements with respect to consistency and completeness down to and including the modular level; b) the decomposition of the design into functional modules and the manner of specification with reference to: • feasibility of the performance required; • testability for further verification; • readability by the development and verification team; • maintainability to permit further evolution; c) the respect of quality requirements. The standard does not contain particular tasks to be performed for design V&V.

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
5.4.4	**Activity: Implementation V&V** This activity addresses software coding and testing. The objectives of V&V are to verify and validate that transformations of the design into code, database structure, and related machine executable representations are correct, accurate, and complete.	**Standard 1** (Section 6.1) states that after the coding phase and before the next phase begins, verification addresses the compliance of the coded computer system software to the software performance specification as derived by the design phase. Section 6.2.2 also defines that the code verification activities begin with module testing and go up through the software by a bottom-up strategy. The purpose of the module testing is to show that each module performs its intended function and does not perform unintended functions. Guidance for code verification activities is given in the software test specification.
5.4.5	**Activity: Test V&V** This activity covers software testing, software integration, software qualification testing, system integration, and system qualification testing. The objectives of V&V are to ensure that the software requirements and system requirements allocated to software are satisfied by execution of integration, system, and acceptance tests.	**Standard 1** (Section 7.5) defines **Integrated system verification** as the process of determining whether or not the verified hardware and software modules have been properly integrated into the system and that the hardware and software are compatible and perform as a system as required by the integration requirements. Section 8 of the standard defines **Computer system validation** as testing that shall be performed to validate the hardware and software as a system in accordance with the safety system requirements to be satisfied by the computer system.
5.4.6	**Activity: Installation and Checkout V&V** This activity addresses software installation and software acceptance support. The objectives of V&V are to verify and validate the correctness of the software installation in the target environment.	**Standard 1** mentions **installation and check-out phase** in definition of the software life cycle, but in other places of the standard the term **commissioning** is used. The standard (Section 10.1.1) defines **commissioning test** as part of **operation activities**. The standard requires that a test program shall be provided to verify the integrity of the installed computer-based safety system with respect to response, calibration, functional operation and interaction with other systems.

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
5.5	**Process: Operation** This activity addresses operational testing, system operation, and user support. The objectives of V&V are to evaluate new constraints in the system, assess proposed changes and their impact on the software, and evaluate operating procedures for correctness and usability.	**Standard 1** (Section 10) states that the term **operation** is used to describe all activities regarding the commissioning and the operation of the system. The term **commissioning** is not used in IEEE Std 1012-1998. The standard defines the commissioning test as part of operation activities (see topic 5.4.6 above). The standard (Section 10.3) also requires that a program for **periodic test** of the safety system shall be defined. The tests shall verify the basic functional capabilities of the software.
5.6	**Process: Maintenance** This activity covers modifications (e.g., corrective, adaptive, and perfective), migration, and retirement of software. Modifications of the software shall be treated as development processes and shall be verified and validated as described in appropriate clauses of the standard.	**Standard 1** (Section 9) states that a formal modification procedure shall be established including verification and validation. After implementation of the modification, the whole or part of the V&V process described in the standard shall be performed again. There is no mention about the migration and retirement of software in this standard.

3.6 Software V&V reporting, administrative, and documentation requirements

Table 5 Comparison of the IEEE Std 1012-1998 Clause 6

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
6.1	**V&V reporting requirements** V&V reporting occurs throughout the software life cycle. The **software verification and validation plan (SVVP)** shall specify the content, format, and timing of all V&V reports. The V&V reports shall constitute the **Software Verification and Validation Report (SVVR)**.	**Standard 1** contains minimal requirements for documentation content. The standard (Section 6.2.1) states that concurrently with the phases of the software development cycle a **software verification plan** shall be established. The plan shall document all the criteria, the techniques and tools to be utilized in the verification process. The standard has no requirement for overall V&V report though particular reporting is required for the verification and validation activities. **Standard 2** contains detailed requirements to the scope and content of verification and justification report of software used for safety justification of objects of atomic energy use.

		Standard 4 (Section 4.2.4) states that records shall be established and maintained to provide the evidence of conformity to requirements. This requirement mentioned for all V&V activities defined in the standard.
6.2	**V&V administrative requirements**	**Standard 1** does not describe V&V administrative requirements. Error resolution is addressed in Section 7.6 for the system but it should be addressed during software-specific phases.
6.3.1	**V&V Test documentation**	**Standard 1** has no special section devoted to the test documentation though the body of the standard. The software test specification and the software test report are required the testing documents. But, this standard addresses test in general.
6.3.2	**SVVP documentation** The V&V effort shall generate an SVVP that addresses the topics described in special clause of the standard devoted to SVVP outline.	**Standard 1** states that a software verification plan shall be prepared by a verification team addressing: a) selection of verification strategies with test case selection; b) selection and utilization of the software test equipment; c) execution of verification; d) documentation of verification activities; e) evaluation of verification results **Standard 4** (Section 7.3.1) states that the organization shall plan and control the design and development of a software product. During the planning, the organization shall determine the review, verification and validation that are appropriate to each design and development stage.

3.7 SVVP outline

Table 6 Comparison of the IEEE Std 1012-1998 Clause 7

Sub-clause number	Main sense of the IEEE standard requirement/statement to be compared	What corresponds/differs in the standards applied in Russia
7	The standard contains detailed SVVP outline.	**Standard 1** has no similar section though Section 6.2.1 describes general requirements to the content of the verification plan (see topic 6.3.2 above)

4. Conclusion

The conducted research has shown that there is no close analogue to the IEEE Std 1012-1998 among the Russian standards, there is no such standard, which is fully focused on the same topic (has the same scope and purpose) and developed based on similar systematic approach.

However, there are several documents applied in Russia, which cover some aspects of the same topic as IEEE Std 1012-1998, see Introduction and the Attachment.

Due to several reasons described in the Introduction the only **IEC 60880-1986** has been selected for the main comparison.

The **IEC 60880-1986** is quite old, application-specific, safety related standard that has the Annex with guidelines on software testing. The standard gives special recommendations for a general approach to software verification and computer system validation. This standard is a system standard in which the software issues are just a part.

This standard has many weaknesses. The major weakness is the standard structure. A reader has to search several places before finding all the requirements for a given process, in this instance, verification.

The body and the appendices are not always consistent (e.g., lifecycle phases). This standard states that it addresses all phases of the lifecycle. In Section 2 the phases are defined as typically being **requirements, design, implementation, test, installation and check-out, and operation and maintenance**. However, in Appendix F (List of Documents Needed) the phases are system **requirements, software requirements, software design, coding, hardware/software integration, computer system validation, commissioning and exploit/maintenance**.

Usually, the body of a standard contains the mandatory requirements. In the IEC 60880-1986, the appendices appear to contain requirements also, and parts of the body appear to be recommendations. Levels of assurance are only hinted at, and "requirements" appear in the form of "should," "shall," "may" priority.

The standard requires that software functional requirements and software design are verified for adequacy. Even if defined, adequacy is not a sufficient attribute to provide the software verification of requirements and design (adequacy is not defined in the standard).

The standard contains minimal requirements for documentation content. While it identifies software engineering practices for the software design and code, it does not require either formal specifications for the software requirements or rigorous static software verification analysis on the requirements, design, and code. Its requirements regarding test activities and error analysis are minimal.

The standard states that software verification ends each lifecycle phase, but the wording is not sufficiently strong to require software verification activities to confirm specification requirements, design, and code.

The software verification plan addresses software verification strategies, selection of test equipment, execution of software verification, documentation of software verification activities, and evaluation of software verification results. It is mentioned that the level of details of the software verification plan shall be such that an independent group can execute it. Nevertheless, there is no strict requirement on independence of software developers and V&V group. Also it does not define software hazard analysis.

The object of comparison – the IEEE Std 1012-1998 is a process standard that defines the V&V processes in terms of specific activities and related tasks. The standard uses the integrity level concept, but is neither a safety-related standard, nor application-specific. This standard defines the V&V to be performed based on four software integrity levels, but these integrity levels are not necessarily safety-related, and can be based on other forms of risk, such as economic, security, etc.

The purpose of software V&V is to help the development organization to maintain the software quality during the software life cycle (IEEE Std 1012-1998, Introduction). From a quality perspective V&V can be seen as an integral part of software quality assurance. If software is part of a larger system, then software V&V can also be considered as part of overall quality management and assurance. The higher level is covered well by corresponding standard (e.g. ISO 9000 family standards). On the other hand the IEEE Std 1012-1998 states that “the user of this standard should consider V&V as part of the software life cycle processes defined by industry standards such as ISO/IEC 12207” (IEEE Std 1012-1998, 1.2 Field of application). Thus, these three standards perfectly supplement each other (e.g. ISO 9000, ISO/IEC 12207 and IEEE 1012 respectively, see Figure 1). First two standards are implemented in Russia as the state standards but there is a lack of standards similar to the IEEE Std 1012-1998, which describes V&V process in needed level of details and quite logical.

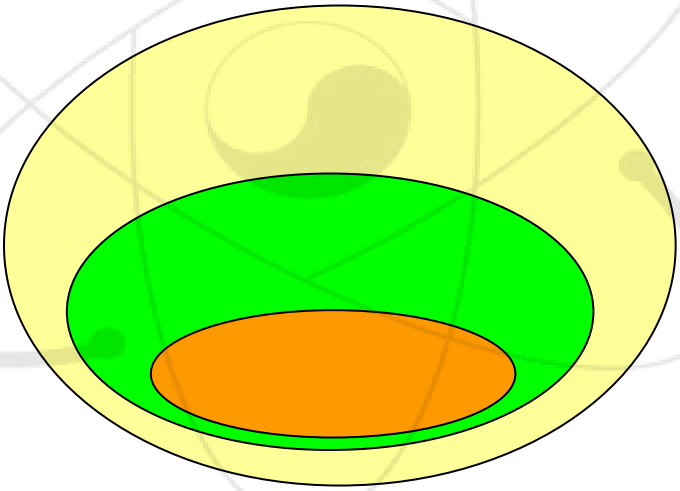

Figure 1. Software V&V in Conext of Quality Management

So, the IEEE Std 1012-1998 standard is much more detailed, comprehensive and strict as compared with the relevant standards applied in Russia for software V&V. There is no Russian standard which is equivalent to the IEEE Std 1012-1998 and a development of such standard (or acceptance of the IEEE Std 1012-1998) could be recommended.

5. Attachment: Brief description of the standards selected for comparison.

GOST R ISO 9000-2001 and **GOST R ISO 9001-2001** contain authentic text from corresponding international standards (ISO 9000:2000 and ISO 9001:2000). These international standards describe fundamentals and specify requirements for a quality management system.

ISO 9001:2000 specifies requirements for a quality management system for any organization that needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements and aims to enhance customer satisfaction. The standard is used for certification/registration and contractual purposes by organizations seeking recognition of their quality management system.

The ISO 9000 family standards are generic in nature and are not designed specifically to any particular industry, product, or service. As a result, the standard provides requirements (what needs to be done) and does not issue specific prescriptive solutions (how to do it).The standards are implemented through a third party process.

To assist in the application of the ISO 9001-2000 standard for the software development industry the guideline ISO 9000-3 (Guidelines for the Application of ISO 9001-2000 to the Development, Supply and Maintenance of Software) was available. This guideline provides guidance to verify that software design, development, production, installation and servicing (maintenance) comply with the clauses of ISO 9001-2000. But this standard still is not implemented in Russia. Furthermore, the standard ISO 9000-3 was under revision during work on this comparison.

RD-03-34-2000 is the Gosatomnadzor of Russia regulatory document. This is application specific, safety related document with comparatively narrow field of application – the software used for safety justification of objects of atomic energy use (neutron calculations, heat transfer and hydrodynamic calculations, radiation protection calculations and so on).

The document contains the requirements to the scope and content of verification and justification report of software used for safety justification of objects of atomic energy use. This report is the basic document justifying possibility of the software to model processes (regimes) of the objects (and/or its elements) of atomic energy use and to calculate the parameters needed for safety justification of this processes (regimes) in stated areas of application.

The document defines the terms verification and attestation (validation), but this definitions are not consistent with definitions stated in other applied in Russia standards (e.g. GOST R ISO 9000-2001 and GOST R ISO/IEC 12207-99).

GOST R ISO/IEC 12207-99 (which contains authentic text of international standard ISO/IEC 12207-95) is standard that defines a framework for software life cycle processes from concept through retirement. The standard provides a common framework that can be used by software practitioners to create and manage software, and by software acquirers for procuring software products and services. It describes five primary processes – acquisition, supply, development, maintenance, and operation. The standard divides the five processes into activities, and the activities into tasks, and places requirements upon their execution. It also specifies eight supporting processes – documentation, configuration management, quality assurance, **verification**, **validation**, joint review, audit, and problem resolution. These represent the processes, activities and tasks required to produce large, complex software systems.

The standard includes processes for verification and validation, but since it is a relatively high-level document, the standard does not specify the details of how to perform the activities and tasks comprising the processes. Nor does it prescribe the name, format, or content of documentation. Therefore, organizations seeking to apply this standard may want to use additional standards or procedures that specify those details (for example the IEEE Std 1012-1998).

Additionally, the standard can be tailored for an individual organization project or application. It is also designed to be used when software is a standalone entity or is an embedded or integral part of a total system. The GOST R ISO/IEC 12207-99 cites ISO 9001 as a normative reference.

부록 VIII

한-러 계측제어 규제용건 비교검토 :

검토 요약

Comparison of the Standards applied to NPP I&C design in Korea and Russia

Summary on standards comparison.

Conclusion Summary

Each main Section of hereby report ends by independent Conclusion. To summarize all the conclusions the following table has been prepared.

Summary table on standards comparison.

#	Standards applied in Korea	Standards applied in Russia, selected for a comparison	Brief conclusion
1.	IEEE Std 603-1998 “IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations”	1. OPB-88/97 (PNAE G-01-011-97) General statements of providing nuclear power plants safety, Moscow 1997 2. PBYa RU AS-89 (PNAE G-1-024-90) Nuclear safety rules for reactors of nuclear power plants, Moscow 1990 3. NP-026-01 Requirements to control systems important to safety in nuclear power plants, Moscow 2001 *Additional standard used for clarification of limited number of definitions and requirements:* 4. GOST 26843-86 Nuclear power reactors. General requirements for control and protection system, Moscow 1986 (new edition in 1989). 5. GOST R ISO 9000-2001 “Quality management systems. Fundamentals and vocabulary”	The conducted research has shown that there is no close analogue to the IEEE Std 603-1998 among the Russian standards. There are several Russian standards, which cover the main aspects of the same topic. The IEEE Std 603 is more comprehensive and useful for the designers of safety systems (namely their I&C portion) than the existing Russian standards. The conducted comparison has shown that in many cases, the criteria and requirements introduced by the IEEE Std 603 are strict enough and even stricter than ones given in the Russian analogues. The examples are: safety systems identification, independence, human factors consideration, etc. However, in some important cases the Russian standards introduce much more detailed and stricter requirements (single failure criteria, reliability). So, a credit can be given to the safety systems based on digital computers, which are designed in accordance with the IEEE Std 603 requirements. Nevertheless, this cannot be done automatically without special expertise of the safety systems on compliance with the Russian standards.
2.	IEEE Std 7-4.3.2-1993 standard “IEEE Standard for	1. OPB-88/97 (PNAE G-01-011-97) General statements of providing nuclear power plants safety, Moscow 1997. 2. PBYa RU AS-89 (PNAE G-1-	There is no full analogue of the IEEE Std 7-4.3.2, which is amplifying computer specific criteria for safety systems, among the Russian standards. The closest

#	Standards applied in Korea	Standards applied in Russia, selected for a comparison	Brief conclusion
	Digital Computers in Safety Systems of Nuclear Power Generating Stations”.	024-90) Nuclear safety rules for reactors of nuclear power plants, Moscow 1990. 3. NP-026-01 Requirements to control systems important to safety in nuclear power plants, Moscow 2001. *Additional standard used for clarification of limited number of definitions and requirements:* 4. GOST 26843-86 Nuclear power reactors. General requirements for control and protection system, Moscow 1986 (new edition in 1989). 5. GOST R ISO 9000-2001 “Quality management systems. Fundamentals and vocabulary” *The most close analogue among the Russian standards:* 6. GOST29075-91 Nuclear instrumentation systems for nuclear power stations. General requirements (OKP 43 6240).	Russian analogue Standard 6 partially covers the same aspects for nuclear reactor I&C. The conducted comparison has shown that in some cases, the criteria and requirements introduced by the IEEE Std 7-4.3.2 are strict enough and even stricter than ones given in the Russian analogue. An example is additional requirement on “Equipment qualification”. However, in a number of important cases the Russian standard introduces much more detailed and stricter requirements (reliability, protection setpoints realization, operating systems usage, etc.). So, a credit can be given to the safety systems based on digital computers, which are designed in accordance with the IEEE Std 7-4.3.2 requirements. Nevertheless, this cannot be done automatically without special expertise of digital safety systems on compliance with the Russian standards.
3.	U.S. NRC Regulatory Guide 1.180 “Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems”	1. GOST R 50746-2000 “Electromagnetic compatibility of technical equipment. Technical equipment for nuclear power plants. Requirements and test methods” 2. GOST R 50745-99 “Electromagnetic compatibility of technical equipment. Uninterruptible power systems. Suppression devices of power mains pulse interferences. Requirements and test methods” 3. IEC 61000-1-2 “Electromagnetic compatibility. Part 1: General, Section 2: Methodology for the achievement of functional safety of electrical and electronic equipment” 4. IEC 61508 (1-7) “Functional safety of electrical/electronic/programmabl	Generally, the U.S. NRC Regulatory Guide 1.180 EMC requirements are strict enough but not comprehensive as compared with Russian standard GOST R 50746-2000 for NPP safety-related I&C equipment/systems. Russian GOST R 50746-2000 contains more types of requirements to EMC immunity of safety-related I&C equipment/systems, which are practically founded on the experience of Russian NPP operation. To harmonize the EMC requirements of safety-related I&C equipment/systems for Russian and foreign NPP the EMC immunity requirements and emission norms of standards IEC 61000-4(-2-95; -

#	Standards applied in Korea	Standards applied in Russia, selected for a comparison	Brief conclusion
		e electronic safety-related systems. Part 1 – Part 7 5. IEC 61000-1-5 “High power electromagnetic effects on civilian systems”	14-2000; -28-2000), IEC 61000-3(-2-95; -3-94), EN 50091-1-2, could be added to U.S. NRC Regulatory Guide 1.180 as normative, but IEC 61000-1-2, IEC 61508-5, IEC 61000-1-5 as informative. To evaluate risk and I&C systems functional safety it is recommended to use the ALARP Principle of IEC 61508-5 and International Nuclear Event Scale.
4.	ANSI/IEEE 344-1987 “IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations”	1. NP-031-01 “Norms for design of earthquake-proof NPPs” *Supplementary documents (mentioned in comparison):* 2. GOST 17516.1-90 ”Electrical articles. General requirement for environment mechanical stability” 3. GOST 16962.2-90 ”Electrical articles. Test methods as to environment mechanical factors stability” 4. IEC 60980	The area of IEEE standard is narrower than Russian standard. The IEEE standard is more technically fundamental, complete and practically useful. Generally, the IEEE standard is comprehensive and strict enough as compared with Russian analogous ones, but some difficulties may be encountered due non-completeness of system of Russian standards and differences in approaches between them.
5.	ANSI/IEEE 323-2003 “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power generating Stations”	1. GOST 25804.5-83 “Atomic power station technological process control system equipment. General rules of conducting test specimens and serial items test acceptance” 2. GOST 25804.7-83 “Atomic power station technological processes control system equipment. Evaluation methods of meeting durability, endurance id resistance requirements for highest influential factors” 3. GOSATOMNADZOR of Russia, RB-004-98 “Requirements for certification of control system important for safety of nuclear plants” 4. Federal norms and rules in the area on the use of nuclear energy. NP-026-01, 2001	While the ANSI/IEEE 323-2003 standard provides the basic requirements for equipment qualification the Russian standards provide more requirements and technical data on specific conditions and regimes to be checked and assessed. In this respect the Russian standards are stricter. From other point, methodological approach of the ANSI/IEEE 323-2003 is more comprehensive and provide modern approach to equipment qualification in a comparison with the Russian standards. For the purpose of mutual certification of the digital I&C equipment designed in Korea and Russia the document RB-004-98 is essential. In particular the document

#	Standards applied in Korea	Standards applied in Russia, selected for a comparison	Brief conclusion
		“The requirements to control system important for safety of nuclear stations” *Standards applied in Russia, selected for an additional consideration*: 5. Federal norms and rules in the area on the use of nuclear energy. NP-026-01, 2001 “The requirements to control system important for safety of nuclear stations” 6. GOST 29075-91 “Nuclear instrumentation systems for nuclear power stations. General requirements”	defines that the procedures for recognition of the certificates issued for SRCS or their component and AM for NPN must be based on the analysis of compliance with the requirements to the systems and components existing in the country of production and the requirements, prescribed for such equipment within Russia; in the purchasing agreement (contract) for the purchase of SRCS, their AM and components imported for a NPP, funding must be allocated for the process of compulsory certification or the procedure of recognition of foreign certificates within the existing certification system.
6.	IEEE Std 1012-1998 “IEEE Standard for Software Verification and Validation”	1. IEC 60880-1986 “Software for Computers in the Safety Systems of Nuclear Power Stations” *Additional standard used for some definitions clarification:* 2. RD-03-34-2000 Gosatomnadzor of Russia regulatory document – “Requirements to the scope and content of verification and justification report of software used for safety justification of objects of atomic energy use” 3. GOST R ISO 9000-2001 “Quality management systems. Fundamentals and vocabulary” 4. GOST R ISO 9001-2001 “Quality management systems. Requirements” *Relevant standard excluded from comparison due to a cross-mapping made in the IEEE Std 1012:* 5. GOST R ISO/IEC 12207-99 “Information technology. Software life cycle processes”	The conducted research has shown that there is no close analogue to the IEEE Std 1012-1998 among the Russian standards. However, there are several documents applied in Russia, which cover some aspects of the same topic as IEEE Std 1012-1998. The IEEE Std 1012-1998 standard is much more detailed, comprehensive and strict as compared with the relevant standards applied in Russia for software V&V. There is no Russian standard which is equivalent to the IEEE Std 1012-1998 and a development of such standard (or acceptance of the IEEE Std 1012-1998) could be recommended.

서 지 정 보 양 식			
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제목/부제	원자력 계측제어계통에 적용되는 한국-러시아의 기술기준 비교
연구책임자 및 부서명 (TR,AR인 경우 주저자)	박 주 현 (미래 원자력 개발단 계측제어/인간공학 연구부)
연 구 자 및 부 서 명	황 인구, 이 동영 (계측제어인간공학연구부)

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연구위탁기관			계약 번호		

초록(15-20줄내외)	본보고서는 러시아에서 원자력 안전관련 계측제어기기에 적용되는 기술기준을 한국에서 적용되는 기술기준에 대비하여 비교 분석한 것이다. 러시아도 다른 나라와 마찬가지로 원자력의 에너지사용에 관하여 전문적인 정부의 위임을 받은 규제기관을 두어 원자력 시설 및 장비의 사용허가, 취소, 감독 등을 수행한다. 러시아에서 원자력 계측제어계통에 적용되는 기술기준을 한국에서 적용되는 하드웨어 및 소프트웨어 기준과 비교한 결과 기본 원칙 및 개념은 같으나 기술기준의 문서체계, 설계요건, 시험항목, 문서의 깊이, 등이 조금씩 다른 경우가 발견되었다. 주요 차이점은 내진검증과 전자기파 기기검증에 있다. 내진검증의 경우 한국에서 적용되는 기술기준은 매우 구체적이고 시험방법이 분명하나 러시아의 기술기준은 다소 개념적이고 분명한 시험방법을 적시하지 않고 있어서 한국의 기술기준에 따라 시험한 결과가 러시아의 기준에 적합함을 시험 후에 문서적으로 증명하여야 할 것으로 분석되었다. 또한 전자기파 기기검증의 경우에는 한국의 기술기준에서 요구하는 시험항목보다 훨씬 많은 항목을 러시아의 기술기준에서 요구하므로 러시아의 기준에 맞추기 위해서는 추가적인 전자기파 시험항목이 필요하다. 그러나 이러한 추가적인 시험항목은 국제전기협회(IEC: International Electrotechnical Committee)의 시험방법을 이용하므로 이들 추가시험항목을 국내에서 수행하는 데는 문제가 없다.
주제명키워드 (10단어내외)	계측제어(Instrumentation and Control), 기술기준(standards), 안전계통(Safety System), 내환경검증(Environmental Qualification), 전자기파장애(EMI, Electromagnetic Interference), 내진검증(Seismic Qualification)

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Abstract (15-20 Lines)

This report describes a comparison result of technical standards applied to instrumentation and control systems for nuclear power plants between in Korea and in Russia. Russia also has a state-run organization authorized to conduct approval, cancellation, and audit in use of nuclear facility or equipment. The Russian standards for nuclear instrumentation and control equipment are analogous with the Korean ones in the aspect of basic concepts and principles. However, there are some differences in document structure, design requirements, qualification test items, depth of contents between two standard systems. The biggest deviation exists in the standard documents for seismic qualification and electromagnetic interference qualification. Korean seismic qualification standard utilizing US approach, defines testing and qualification methods specifically and clearly. Russian standards however provide only conceptual definitions and requirements in the seismic related aspects. Therefore, it is conceived that any equipment or system qualified seismically in accordance with Korean standards should additionally provide technical evidence that it is satisfactory with Russian standards as well. In electromagnetic interference qualification, because Russian standard requires more testing items than the current Korean standard, the additional qualification tests are necessary to meet the Russian requirements. However, these additional test items are based on IEC(International Electrotechnical Commission), therefore it is not a problem to perform those tests in a Korean testing facility.

Subject Keywords (About 10 words)	Instrumentation and Control, Standards, Safety System, Environmental Qualification, EMI(Electromagnetic Interference, Seismic Qualification