IAEA–CN-156-S-3/OR

Effectiveness of Safety Regulation at Russian Research Reactors in Compliance with International Practice

Alexander Sapozhnikov

Federal Environmental, Industrial and Nuclear Supervision Service of Russia (Rostechnadzor), Moscow, Russia

E-mail address of author: sai@gan.ru

Introduction.

Russia possesses a set of Nuclear Research Installations (NRI)[1] of different type and experimental abilities. The experience of safety regulation at Russian NRIs that has been created and developed in 50-80th of XX century is important both for Europe Region and international collaboration as a whole [1]. The part of IAEA plan for enhancement of safety at NRI consists of the Code of Conduct on the Safety of Research Reactors that has been adopted by the Board of Governors in 2004. The Code should serve as guidance for development and harmonization of national policy, legal framework and regulations for safety of research reactors. The summary of practice of safety regulation at Russian NRI is given in the report on the basis of the Code's theses. The objectives of the analysis are the following: 1) to create an understanding on any significant differences in substance with regard to NRI safety requirements; 2) to suggest appropriate steps to move towards a harmonized approach to safety of NRI in accordance with international practice. Other practical issue considered in the report concerns definition of a set of performance indicators for NRI and estimation of efficiency of regulatory activity to improve those indicators [2,3,4].

1. The State System for Safety Regulation of the Use of Nuclear Power in Russia.

The state regulatory framework of the use of nuclear power in Russia has been established in 1983 year and had a few stages of development [5]. In result of administrative reform of governmental system and according to orders of President of Russia the Federal Environmental, Industrial and Nuclear Supervision Service of Russia (Rostechnadzor) has been established in 2004. The further information about Rostechnadzor is available on web site www.gosnadzor.ru. The general objective of Rostechnadzor's activity is to promote protection of supervised hazardous objects, staff of those objects, population, and environment against potential harmful threats.

Responsibilities and liability of the Authority are in compliance with Code of Conduct on the Safety of Research Reactors (Article V «Role of the State»). The principle of prime responsibility of operating organization for safety was established at legislative level in Russia. Rostechnadzor is a federal executive authority which implements major functions of a body for state regulation of safety in the use of atomic energy including submission of the draft federal laws, legal acts and regulations to be issued by the President of the Russian Federation and the Government of the Russian Federation, development of standards and regulations, authorization of activities, analysis and assessment of safety; inspections and sanctions. Rostechnadzor's competence includes organization and providing for functioning

[1] NRI - will be interpreted as structures and complexes with research nuclear reactors (RR), critical (CA) and subcritical (SCA) nuclear assembles that have been designed for utilization of neutrons and ionizing radiation for research purposes.

of the monitoring system with regard to nuclear facilities in case of emergency situations (emergency response). Some Code's theses of the Article V «Role of the State» have not been implemented yet in the full scope and are being developed. Among unresolved theses of the Code are the followings:

- item 11: (*to provide the regulatory body with adequate resources to ensure that it can discharge its assigned responsibilities)* - there is no state educational system for strengthening the staff of regulatory body;
- item 13: (*to ensure financing of the operating organization for safe operation of research reactor, for maintaining the research reactor in a safe shutdown state for extended periods if this becomes necessary, and for its decommissioning)* - the most of operating organizations have a financial problem to remove radioactive wastes and spent fuel, to provide backfitting of NRI to up-to-date safety requirements;
- item 14: (*to establish an effective system of governmental emergency response and intervention capabilities relating to research reactors)* - some sites of NRI have insufficient level of emergency preparedness; the emergency center of Rostechnadzor has not been equipped for monitoring during an accident at NRI;
- item15: (*to make adequate legal and infrastructural arrangements for decommissioning of research reactors* – there is a lack of legislative and economic tools to facilitate decommissioning of NRI in case of need.

The general problem both for safety ensuring and regulation in Russia is uncertainty of programme for utilization and development of NRI. Facing with new needs and challenges related to development of nuclear power and technologies in Russia the development of experimental facilities and the strengthening of regulatory impact of Rostechnadzor shall be urgent issue.

2. The Legal and Regulatory Framework of the Use of Nuclear Power in Russia.
Hierarchy and full list of legislation, safety standards and regulations that Rostechnadzor used for safety regulation of the use of nuclear power are given in reference [6].

The activity in the field of the use of atomic energy for peaceful and defense purposes (excluding nuclear weapon and military nuclear power installations) is regulated by the Federal Law "About the Use of Atomic Energy" (1995). The legislative fundamentals of radiation safety are established by Federal Law "About Radiation Safety of the Population" (1996). An interaction between the society and environment is regulated by Federal Law "About an ecological expertise" (1995) and Federal Law "On the Protection of Environment" (2002), administrative punishments are defined in "The Code on Administrative Infringements" (2001). Strategy for improvement of the quality of products is based on realization of Federal Law «On Technical Regulating» (2002). The drafting of Technical Regulations for nuclear and radiation safety is being carried out according to this law. The fundamental requirements are based on recommendations of Worldwide Trade Organization to establish proper conditions for unified approach both to safety ensuring of different kinds of industrial objects and quality of products [7]. Nowadays works for development of the legal system of Russia are being continued to enhance safety of the use of nuclear power and to strengthen the role of nuclear regulatory body of Russia.

In accordance with Federal Law on the Use of Atomic Energy the set of safety standards (Federal Norms and Rules) that includes all live cycle of installations has been developed and implemented in Russia. This set includes the following documents of Federal Level:

General Regulations

- NP-033-01 General Regulations for NRI Safety (2002);
- NP-042-02 Requirements to Quality Assurance Program of NRI (2003);

Safety Requirements

- NP-048-03 Nuclear Safety Rules for Pulse Reactors (2003);
- NP-008-04 Nuclear Safety Rules for Criticality Stands (2004);
- NP-009-04 Nuclear Safety Rules for Research Reactors (2004);
- NP-059-05 Nuclear Safety Rules for Subcriticality Stands (2005);
- SP IR-03 Sanitary Rules on Design and Operation of Research Nuclear Reactors (2003);

Decommissioning

- NP-028-01 Safety Rules for Decommissioning of NRI (2001);
- Emergency Preparedness
- NP-027-01 Provisions on Investigation and Reporting of the Operational Violations at NRI (2001);
- NP-075-06 Requirements to the Contents of Emergency Plan for Personnel of Nuclear Research Facility (2006);

Requirements to Safety Justification

- NP-049-03 Requirements to the Content of the Safety Analysis Report for NRI (2003).

Also the set of standards has been developed for all kind of atomic objects including radiation safety norms and sanitary rules, safety requirements for equipment, physical protection, requirements for works and services concerning treatment with radioactive wastes, nuclear materials, and radioactive substances.

To promote development of Probabilistic Safety Analysis for NRI the following reference points were included in the documents NP-033-01 and NP-009-04:

- Unavailability to scram the reactor should not be more than 10^{-5} (probability of rigorous damage of the core of NRI);

- Probability less than 10^{-7} per year at one NRI for maximum radioactive release to environment in case of an accident that lead to use the emergency plan of protection of population.

Development of PSA in addition to deterministic analysis of defense in depth concept will promote better understanding of NRI behavior and will indicate the strengths and weaknesses of the design and operation procedures of facility.

The graded approach to NRI safety requirements is being used in national regulations depending on magnitude of their potential hazard involved. Related to potential consequences of Design Basis Accident and Beyond Design Basis Accident the following NRI classification had been established:

Group 1: RRs (high flux and test) with constant neutron flux of nominal power up to and above 100 MW, for which a potential of severe accident covers all range of INES. Mainly the RRs of this group intend for materials research and equipment test (PIK, SM-3, MIR.M1, BOR-60, VK-50);

Group 2: RRs with forced cooling system of nominal power up to 20 MW, for which a risk exists of off site emergency. RRs of this group intend for fundamental physics research and applied sciences in the field of physics, chemistry, biology, medicine, isotopes production and training (IRT-MIPhI, IRT-T, IR-8, IVV-2M, WWR-Ts, WWR-M, RBT-6, RBT-10/2);.

Group 3: RRs of nominal power up to 1 MW, also CA, SCA that are of “zero” power, which do not need any forced cooling system in emergency. A risk of emergency is limited by indoor of facility only. NRIs of this group intend for physics study of nuclear core, study

relating to industry and environment safety (OR, IR-50, U-3, ARGUS, F-1, GIDRA, BARS-4, BARS-6, IBR-2).
Progress has been achieved in the preparation of appropriate guiding documents related to organizational structure of state regulatory authority, licensing and authorizing procedures; implementation of effective control and supervision over nuclear activities, transparency of regulatory activities; improvement of the level of professional skills.

The safety requirements of national standards and regulations cover the majority of Code's recommends and there is no any contradiction between requirements. The national requirements capacity covers all thematic issues in sphere of nuclear and radiation safety and corresponds to IAEA approach to national regulatory framework declared in document [8]. The major peculiarities of Russian standards in compliance with Reference Levels of Article VI "Role of the Regulatory Body" of the Code are given in TABLE 1.

TABLE 1. MAJOR RESULTS OF COMPLIANCE THE NATIONAL REGULATIONS ON SAFETY WITH THE SET OF REFERENCE LEVELS OF THE CODE (ARTICLE VI, ITEM 20)

Item	Content of the Code's Recommendation	Peculiarities of National Regulatory Framework
Assessment and verification of safety		
20c	Operating Organization (OO) should to undertake periodic safety reviews (PSR) at intervals determined by the regulatory body and to make proposals for upgrading and refurbishment arising from such reviews as necessary.	Requirements for PSR is absent in national standards. Licensing Conditions (LC) for operation of NRI include requirement that OO shall undertake review of NRI safety regarded to new implemented regulations with purpose to upgrade and refurbish design as a result of such review as necessary.
Financial and human resources		
20d	OO should to demonstrate that it has sufficient financial and human resources to support safe operation of the research reactor.	Procedure and format of document to recognize ability of the organization to operate NRI have not been determined.
Siting		
20k	The regulations and guidance established by the State or the regulatory body should establish criteria for the siting for research reactors.	Criteria for the siting of research reactors has not been established in national regulations.
Operation, maintenance, modification and utilization		
20o	OO should to establish operational limits and conditions for the research reactor, with the regulatory body to assess and approve the limits and conditions and changes to them.	Set of operational limits and conditions shall be submitted for authorization in specified document that has not been developed by the most of OOs. Operational limits and conditions dispersed in different kinds of documents.
Decommissioning		
20u	The regulations and guidance established by the State or the regulatory body should establish criteria for the release from regulatory control of decommissioned research reactors.	Criteria for release of decommissioned NRI from regulatory control have not been established in national regulations.

As outcomes of the analysis the needs for further harmonization of national requirements for safety of NRI were identified. Some standards have to be revised and a few standards have to be developed: requirements of NP-028-01 should be detailed for comprehensive engineering characterization and radiation monitoring during NRI decommissioning; SAR for NRI decommissioning should be developed in details; emergency preparedness and response at NRI site should be strengthen, scope of requirements of NP-027-01 should be extend on decommissioning stage of NRI, criteria for NRI siting and criteria for release site from regulatory control after the NRI have been decommissioned should be developed.

4. Overview of Current Safety Status at Russian NRI

At present Rostechnadzor conducts the state safety regulation and supervision at 76 civil NRI operated by 19 organizations, which have got different financial and human resources. These organizations are governed by two Federal Ministries of Russia, four Federal Agencies, one International Intergovernmental Organization, and Russian Academy of Science that is fund and self-governing organization. The utilization factor of the powerful RRs (1st and 2nd groups of potential hazards) is in range 0,5-0,9.

Approach of annual self-assessment of safety has been implemented in operating organizations and is used in regulatory practice for more than 10 years. The commensurate reports are submitted to regulatory body for review of current safety and ensure corrective action for deficiencies and planning of inspections. The requirements to contents of the report are regulated by manual RB-025-03 (2003). Performance indicators for NRI were classified into generalized parameters decisive for safety that are given in TABLE2.

TABLE 2. GENERALIZED PARAMETERS DECISIVE FOR SAFETY OF NRI

№	Group factors decisive for safety	Expert's evaluation	Satisfactory	Insufficient	Low	Inadmissible
			green	brown	yellow	red
1	Fulfillment of license conditions, realized design amendment and changes					
2	Current state of safety barriers and safety systems					
3	Deviations from normal operation					
4	Releases to environment, personnel exposure, radiation conditions and monitoring					
5	Handling with spent (irradiated) fuel and radwastes, sources of ionizing radiation, accounting of nuclear materials					
6	Operation management, personnel training					
7	Characterization of maintenance and repairing					
8	Current state of physical protection					
9	Realized measures for safety enhancement					
10	Emergency preparedness and training					
11	Unsolved safety problems					

The expert's evaluation is being carried out on data included in the annual report for components of each generalized parameter decisive for safety. The safety status of NRI in result of evaluation shall be classified according to regulations RB-037-06 in four safety levels. The new regulations RB-037-06 was approved in 2006 and this approach is being implemented in regulatory practice for safety of NRI.

When discovered deficiencies of safety are impossible to eliminate the decision is taken to terminate the nuclear activity at NRI and further decommissioning. For example, as the result of current safety analysis the Ministry of Atomic Energy took the decision of final shutdown of two RRs in 2002: AM-1 (the First NPP in the World, 1954, channels in graphite, 10Mw), BR-10 (LMFR type, 8 MW).

According to License Conditions for operation of NRI and in compliance with procedures, which were determined by governmental degrees (1997, 2005), the operating organizations should provide accumulation of special fund for upgrading and decommissioning the NRI. However in real economic circumstances the tool to accumulate fund by OO is inefficient. At present NRI cannot be self-supporting due to scarcity of financial accumulation and the state financial support is necessary first of all to provide safety or decommissioning of NRI. Thereupon the decommissioning of RRs - TVR (1949-1988, tank heavy water, 2,5MW) and MR (1964-1992, test reactor, channel in the pool, 50 MW), is being carried out under financial support of the European Commission.

Incidents investigation, reporting and analysis are carried out at all NRI according to requirements of NP-027-01. Flowchart of NRI incident reporting system is given at FIG.1.

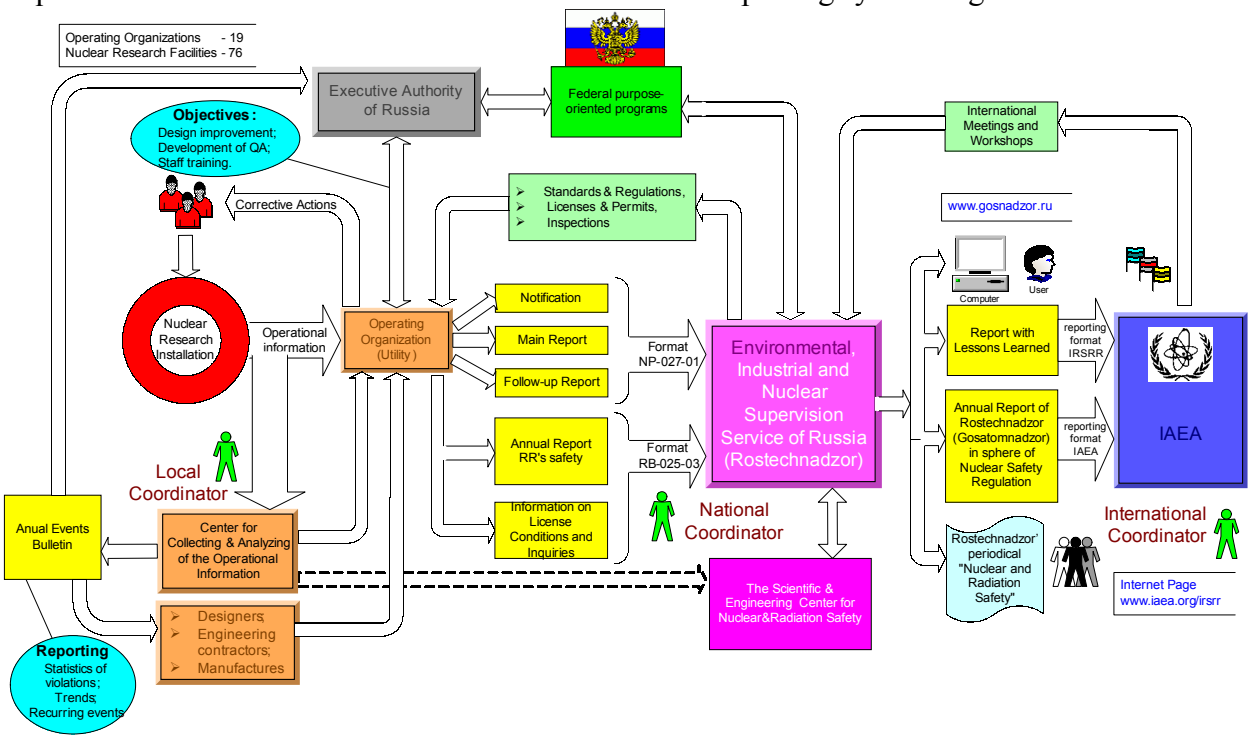

FIG.1. FLOWCHART OF REPORTING AND PROCESSING SYSTEM OF NRI

The incident reporting system includes two levels: 1) level of Operating Organization (local coordinator); 2) level of Regulatory Body (national coordinator). The information about events, which are the most important as lessons learned, is being published in Rostechnadzor periodical “Nuclear and Radiation Safety” and reports is being transmitted in IAEA format to Incident Reporting System for Research Reactors (IRSRR).

All happened operational events that have been reported to regulatory body did not result to exceeding of limits of personnel exposure or contamination of environment beyond prescribed limits. Since 1990 till September 1, 2007 there were registered 880 unplanned RRs shutdowns including: 338 events that caused by problem of off-site power supply system (short-term undervoltage, voltage breakdown); 394 – cased by malfunction of instrumentation, control systems, electrical or heat-mechanic equipment; 42 – due to malfunction of experimental devices and facilities; and 106 events happened because of personnel errors [9]. Changing of the number of incidents happened at NRI is shown at FIG.2.

In April 1996 on the basis of events analysis RF Gosatomnadzor[2] established the obligatory procedure to approve by Field Inspection an opportunity of OO to continue the operation at power level after the reactor scram. Taken preventive measure has been effective to reduce personnel errors. Further possible way to raise the level of technological and operating discipline could be development of regulations "Technological Regulations of NRI" on the basis of IAEA document «Operational limits and conditions for research reactors».

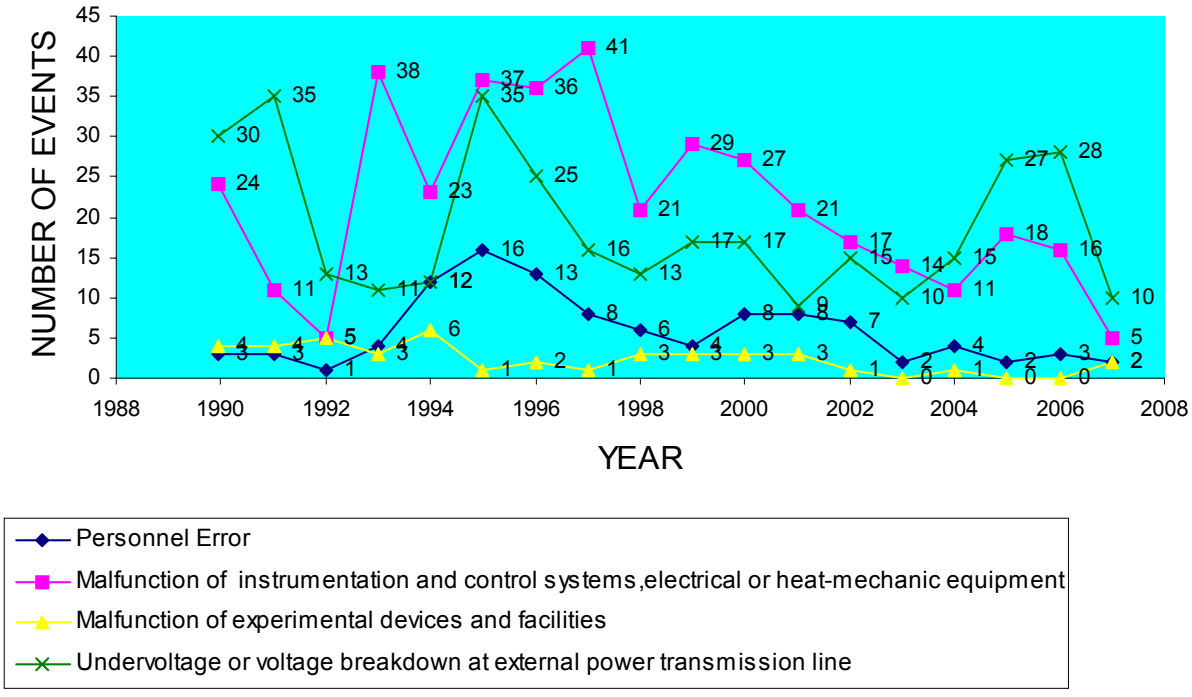

FIG2. CHANGING OF THE NUMBER OF INCIDENTS AT NRI

During the recent years many reactor scrams happened due to instability of off-site electric power supply (2006- 60% of scrams).This events usually are not in force of the reactor manager and related to insufficient reliability of external power supply due to imperfection of old design system. The need for reconstruction would require substantial investments. The basis for improvement is the fact that sphere of Rostechnadzor activity covers regulation both atomic objects and electric networks on the basis of unified approach to safety.

Gaseous releases and liquid emissions of RRs are essentially less than maximum permissible limits of effluents and usually less than the reference levels established by OO to control trends.

The radiation dose rate to staff of NRI and attracted workers essentially less than reference and permissible levels. Depend on kind of facility and occupational category of staff the individual dose of radiation exposure on average is from 2 mSv to 15 mSv per year whereas the reference limit is 20 mSv/a and permissible level is 50 mSv/a.

The problem of spent fuel transportation from RRs sites remains till now because of soaring cost of transportation and reprocessing at special enterprises and this cannot be solved only by enforcement measures of Rostechnadzor. Mainly spent fuel and radioactive wastes are concentrated on the territories of ten scientific centers: Russian Research Center "Kurchatov Institute", Research Institute of Atomic Reactors; Institute of Physics and Power Engineering;

[2] RF Gosatomnadzor – Federal Nuclear & Radiation Safety Authority of Russia (1991-2004)

Institute for Reactor Materials Research; Konstantinov Petersburg Nuclear Physics Institute of Russian Academy of Science; Filial of Karpov Institute of Physical Chemistry; Join Institute for Nuclear Research, Institute for Instrumentation Research, Tomsk Nuclear Physics Research Institute, Moscow Engineering Physics Institute.

All NRI have on-site emergency plans. The sites with facilities of 1st and 2nd groups of potential hazards have also off-site emergency plans. Personnel training on emergency situations are conducted on a regular basis.

Modernization of equipment and systems, upgrading of fire protection and physical protection are being carried out during implementation of license conditions at the most of NRI in operation. In spite of existing issues of safety Rostechnadzor estimates the current status of Russian NRI safety as satisfactory taking into account compensatory measures provided by OO.

For replacement of removed from operation facilities the following works are carried out: construction of high flux reactor PIC, 100 MW (Gatchina); construction of Accelerator Driven System "Electro-Nuclear Neutron Generator"(Moscow); reconstruction of the pool-type research reactor IRV-M1, 4 MW (Litkarino); planning of modernization of pulsed reactor IBR-2 and construction of ADS "Intense Resonance Neutron Source" (Dubna).

5. Effectiveness of Safety Regulation at NRI.

The quality indicators of regulatory activity on nuclear and radiation safety are followings: absence of events with radiation overexposure of personnel and population; absence of accidents; absence of incidents of nuclear materials and radioactive substances embezzlement.

At present quantitative estimation of regulatory efficiency cannot be done reliable because of complexity of performance indicators, variety of supervised objects, diversity of regulatory functions and lack of reported statistical data. Nevertheless search of reasonable indicators to plan regulatory activity is being continued. The Government of Russian Federation approved indicators for Rostechnadzor activity [10]. The list of indicators and formulas for their estimation are given in TABLE 3. Results of specific estimation of the indicators and their predictable evaluation for NRI are shown at FIG 3. The indicators might be estimate for each Rostechnadzor's Inspectorate (Field Inspection, Territorial Office). Nowadays the electronic database (DB) of NRI documentation is being created within national project «Strengthening of Emergency Preparedness and Response at Nuclear Research Facilities» (RUS/9/005) in the frame of IAEA technical collaboration. Engineering solutions that have been taken in project can provide processing of statistical inspection data, estimation of performance indicator of NRI and indicators of regulatory activity.

The following problems and risk factors make an impact on final results of Rostechnadzor's activity:

- Aging of equipment and systems important for safety;
- Aging of personnel and its leak;
- Deficiency of knowledge management system;
- Insufficient management of OO in analysis of new regulations;
- Insufficient of safety provision as a result of reorganization of enterprises due to changing of owners, merging enterprises to stock company and other changes of management;
- Incompleteness of legislation in sphere of the environment protection;

- Insufficient level of logistical and information support of emergency preparedness.

The result of analysis shows the following:

- Comparative stability of indicators for 2005-2007 years;
- Decreasing of inspectors man-hour per inspection;
- Decreasing of number of discovered violations of regulations;
- Necessity to take measures to reduce “Level of reportable events” ;
- Necessity to take measures to reduce “Level of negative impact to environment” and minimization of all kinds of RAW.

TABLE 3. PERFORMANCE INDICATORS PRESCRIBED FOR REGULATORY ACTIVITY.

№	Indicator		Formula of calculation
Indicators of Final Results			
1	Level of reportable events		$\downarrow R = \frac{A/O}{A_{av}/O_{av}}$
2	Intensity of inspections		$\uparrow S = \frac{I/O}{I_{av}/O_{av}}$
3	Effectiveness of inspections		$\uparrow E = \frac{S}{R}$
4	Level of negative impact to environ-ment	Gaseous releases (W_G)	$\downarrow W = \frac{M_n}{M_{n-1}}$
		liquid emission (W_F)	
		distributed Liquid and Solid Radwastes (W_D)	
Process Indicators			
5	Efficiency of supervision		$\uparrow F = \frac{V}{I_f}$
6	Level of administrative demands		$\downarrow D = \frac{V}{P}$
7	Development of Technical Regulations and Standards		$\uparrow N$

A – amount of reportable events (accidents, incidents);
A_{av} – average amount of reportable events for 5 years before the reporting year;
O – actual number of supervised NRI in the reporting year;
O_{av}– average number of supervised NRI for 5 years before the reporting year;
I – amount of inspections conducted at supervised NRI in the reporting year;
I_{av} – average amount of inspections at supervised NRI for 5 years before the reporting year;
$M_{(n)}$, $M_{(n-1)}$ – bulk of contaminant to atmosphere, water and distributed wastes in reporting year (n) and previous year (n – 1);
Output of NRI is radioactive gaseous, liquid and solid effluents (RAW). The regulatory activity shall promote minimization of all kinds of RAW. As an estimation of regulatory activity to minimize quantity of RAW the relative changing of RAW at site was taken. The total accumulation of RAW at sites of NRI practically does not depend on total energy produced at NRI (that defines by the time of operation of the most powerful facilities).
V – number of discovered violations of safety requirements in the reporting year;
P – number of enforcement measures (works laying-off) and sanctions (penalties) in the reporting year. Penalty is very seldom at NRI (1998-1 time; 2006-4 times).

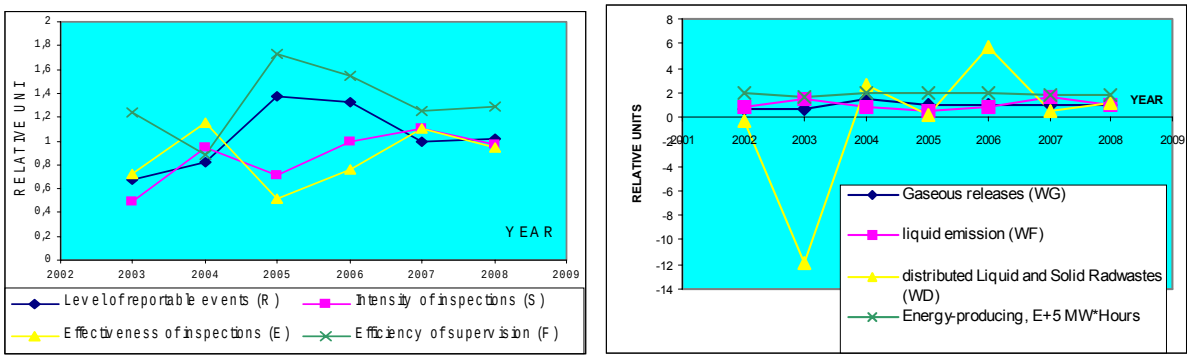

FIG.3. EVALUATION OF PERFORMANCE INDICATORS OF REGULATORY ACTIVITY AND THEIR PREDICTION

6. The Findings of the Regulatory Practice of NRI in Russia

Rostechnadzor keeps adherence to fundamental IAEA safety principles to protect people and environment from harmful effect of radiation [11]. Activity of Rostechnadzor directs to implementation of IAEA requirements related to the legal and governmental infrastructure for the safety of nuclear facilities and activity in the sphere of the use of nuclear power [12]. New needs of development of nuclear engineering and technologies planned in Russia at present are based on harmonious improvement of national legislative and normative framework of the use of nuclear power, enhancement of safety culture and strengthening of regulatory impact.

On the base of theses of the Code of Conduct on the Safety of Research Reactors the following results have been found out as findings of safety regulation analysis at Russian NRI:

1. The set of safety requirements of Russian standards in the whole corresponds to IAEA approach to national regulatory framework for NRI.
2. The analysis of national regulatory framework for NRI in compliance with reference levels of the Code of Conduct on the Safety of Research Reactors has let to move towards a harmonized approach to safety of NRI.
3. Considered method of Performance Indicators might be useful for managers of top level to control, to plan and to predict regulatory activity.

REFERENCES

[1] Final Document of the International Conference "RESEARCH REACTORS IN THE 21st CENTURY", 20-23 June 2006, Moscow, NIKIET. http://www.nikiet.ru/eng/conf/index.html.

[2] Assessment of regulatory effectiveness, Peer discussion on regulatory practices, PDRP-4, IAEA, 1999.

[3] Direct Indicators of Nuclear Regulatory Efficiency and Effectiveness, Pilot Project Results, NEA №3669, OECD 2004.

[4] Western European Nuclear Regulators' Association (WENRA), Report by WENRA Reactor Harmonization Working Group «Harmonization of Reactor Safety in WENRA Countries», January 2006.

[5] Safety of Russia. Legal, Socio-Economic and Scientific and Technical Aspect. Regulation of Nuclear and Radiation Safety. Moscow: "Knowledge", 2003.

[6] The List of Legislative Acts and Normative Documents related to sphere of Rostechnadzor activity, P-01-01-2006, Rostechnadzor.

[7] Recommendations of Development of Technical Regulations R 50.1.044–2003, Publish House of Standards, Moscow, 2003.

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Documentation for Use in Regulating Nuclear Facilities, Safety Standard Series № GS-G-1.4, IAEA, Vienna, 2002.

[9] A. Sapozhnikov "Development of Occurrence Reporting System at Nuclear Research Installations for Prevention of Operational Events related to Human Factor", Proceeding of Scientifically-technical Conference "Human Factor of Nuclear Energy and Industry Safety", 17 – 20 September 2007, Russian Federation, Kaluga region, Obninsk.

[10] Report of Federal Environmental, Industrial and Nuclear Supervision Service of Russia on Results of Activity and Major Directions of Activity on 2007 – 2009, Moscow, 2006 г. http://www.gosnadzor.ru/slugba/doklad2007_2009.html

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, Safety Fundamentals, № SF-1, IAEA, Vienna, 2006.

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety Requirements, Safety Standard Series №GS-R-1, IAEA, Vienna, 2000.