The Analysis of Risk of the Radiation Failures in Russian Navy - Experience of International Cooperation

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Radioecological situation in Northern region of Russia is determined, in basic, operation and service of the ships of Naval fleet with nuclear power plants (NPP).

At normal operation of the ships with NPP a high level of nuclear and radiation safety is as a whole provided. Possible radioecological impact on environment connected to emergencies as directly on the ships, so on objects of their service (ship-repairing factories, service vessels, storages of spent nuclear fuel and radioactive watse).

In connection with unsufficient development of objects of an infrastructure, the hardware of which does not answer the modern requirements, recently a situation in separate points of region, especially in items for storing of spent nuclear fuel, gets crisis character.

The objects of Navy - nuclear submarines and ships, service vessels and coastal structures are the really hazard as the potential sources of radioactive contamination of environment and exposure of people.

In 40 years of operation on objects Navy heavy failures, resulting to significant radioactive releases and exposure of personnel by high doses of radiation, took place. In the table 1 data on failures on soviet nuclear submarines are resulted.

Table 1

The analysis of the reasons of some failures and wrecks of soviet nuclear submarines

Tipe of submarine, items of basing, name under the directory "Jain's Intellingence Review "	**Date and place of wreck, failures submarine**	**Quantity of lost**	**The reasons of failure, wreck submarine**
1	**2**	**3**	**4**
Nuclear submarine "□-8", "November"	13.10.1960 Barents sea	The high doses of radiation at 13 persons	Failure of nuclear power installation
Nuclear submarine "□-19", "Hotel-11"	4.07.1961 The northern part of Atlantic ocean	8 persons	Failure of nuclear power installation
Nuclear submarine "□-11", "November"	10.02.1965 Severodwinsk	The high doses of radiation at 7 persons	Uncontrollable output on capacity reactor
Nuclear submarine "□-3", "November"	8.09.1967 Norway sea,1700 miles to the base	39 persons	The fire in 1 and 2 compartments
Nuclear submarine "□-27"	24.05.1968 Barents sea	9 persons	Failure of nuclear power installation
Nuclear submarine "□-140", "Yankee"	23.08.1968	_	Uncontrollable output on capacity reactor
Nuclear submarine "□-19", "Hotel-11"	15.11.1969 Barents sea	_	Collision on depth 60 m with USA submarine
Nuclear submarine "□-8", "November"	8.04.1970 The Galf of Byskay, 300 miles to Spain	52 persons	The fire in 3 and 7 compartments, receipt of water, is submerged on depth 4.680 m
Nuclear submarine "□-19", "Hotel-11"	24.02.1972 600 miles to Newfaundlend island	28 persons	The fire in 8 and 9 compartments
Nuclear submarine "□-171". "Delta"	28.12.1978 Pacific ocean	3 persons	Failure of nuclear power installation

Table 1 (continuation)

1	2	3	4
Nuclear submarine "□-162"	30.11.1980 Severodwinsk	–	Uncontrollable output on capacity reactor
Nuclear submarine "□-429", "Charlie-1"	23.06.1983 4,5 to the coast of Krachenynnickov bay	17 persons	Receipt of water
Nuclear submarine, "Echo-2"	18.06.1984 Barenz sea	14 persons	The fire in compartment
Nuclear submarine, "Echo-2"	10.08.1985 Chazhma harbor, Shkotovo-22	10 persons	Uncontrollable output on capacity reactor
Nuclear submarine "□-219", "Yankee"	6.10.1986 480 miles to Bermudes islands	4 persons	Explosion in rocket shaft, is submerged on depth 6.000 m
Nuclear submarine "□-278", "Komsomoletz", "Maik"	7.04.1989 Norway sea, 100 miles to Medvejy island	42 persons	The fire in compartments, receipt of water, is submerged on depth 1.655 m
Nuclear submarine "□-192", "Echo-2"	26.06.1989 Barents sea, 300 miles to the base	–	Failure of nuclear power installation

At the present time the number of nuclear submarines, taken out of operation, on which it is necessery to refuel nuclear reactors and dismantle certain equipment of their reactor compartments is being increased. More than 150 nuclear submarines have been already taken out of operation, almost a half of them - on the Northern Fleet. Only 1/3 of removed submarines have their nuclear reactors defueled. In the nearest years floating technical bases for submarine reactors refueling with storages of spent nuclear fuel, which have finished their service life, are also to be condemnated. The aggregate of previously presented data allows to estimate a radioecological situation in sites of basing, refueling and repair of the Northern Fleet ships with nuclear propulsion plants as normal, supplied with adequate radioecological monitoring. At the same time imperfection of the infrastructure ensuring collection, storing and processing of radioactive waste demands implementation of a complex of urgent and sophisticated measures, directed to the improving safety of these objects (1-7).

The first operation to refueling a submarine's reactor in the Northern Fleet took piace in 1961 in Zapadnaya Litsa. The reactor of the "K-14" submarine (project 627} was reloaded with the use of the floatiing maintenance base PM-124 (project 326) and floating workshop PM-6 (8).

Temp of unloading of SNF from nuclear submarines do not exceed 5-6 active zones in a year and it is possible to consider, that the period of storing of separate nuclear submarines with used active zones without acceptance of effective organizational and technical measures will be prolonged of even more 20 years.

The conditions of storing of SNF (level of temperatures, absenceof heat removal, quality of environment render small influence to a condition of elements of an active zone and at observance of the requirements store it will not practically change. Hence, the corrosion factor does not impose restrictions for the term of storing of an active zone, which can considerably exceed established service life of an active zone. This conclusion is not distributed to zones with partially non-hermetic jacket of fuel elements, in which contact of environment with fuel is possible.

The analysis of a mode long-duration storing of active zones in reactors shows, that it can considerably be simplified dewatering of 1 contour. Besides and first of all, dewatering largely solves the problem of nuclear safety. After dewatering organization of storing with the minimum service, on non-equipped wharfs and, probably, without observance of a temperature mode is possible. The organization of unloading of an active zone from dry reactor excludes an opportunity of occurrence of nuclear failure at infringement of technology of unloading.

Liquid radioactive wastes generated during the operation of nuclear-powered vessels are storing in both coastal and floating containers. The volume of all available containers for the Northern Fleet is 10.000 m3 but 30% of these are unfit for use. The amount of liquid radioactive wastes from the Northern Fleet is estimated to be 7.000 m3 containing a total activity not exceeding 3.7 TBq. About 2.000-2.500 m3 of liquid wastes are generated annually but there are essentially no empty containers in which to store them. Liquid wastes of the Northern Fleet are partly transported for processing at Atomflot (9). In 1994-1996, the amount of liquid radioactive wastes processed was 1.500 m3 .

Solid radioactive wastes are stored in storage facilities and on open temporary storage sites which were largely built in the 1960s and 1970s and do not fully meet the requirements for environmental protection. High-level wastes are stored in special facilities only. The amount of solid radioactive wastes in the Northern Fleet is estimated to be 8 000 m^3 with a total activity not exceeding 37 TBq. On average, 1000 m3 of solid radioactive wastes are generated annually. Considering the increasing rate of submarine decommissioning, the rate of generation of radioactive waste may increase by at least a factor of two. The major storage sites for solid radioactive wastes in the Northern Fleet are Andreeva Bay, Iokan'ga and Poljarny. By volume, 50% of the solid wastes are combustible, 15% are compressable, 35% are non-compressable and 1% are spent ion-exchange filter resins. No processing of solid radioactive wastes currently takes place in the Navy. Numerous plans and projects to build and reconstruct facilities for radioactive waste storage and processing have not been completed and implemented because of limited financial resources (9).

According to Russian Federal Program approved by the government in 1995, handling and disposal of radioactive waste and spent nuclear fuel including decomissioning of naval nuclear reactors will be significantly improved in 1996-2005. But apropriate measures are being implemented slowly because of present economical problems in Russia (10, 11).

The international research program **“Risk and nuclear waste: nuclear problems, perception of risk and the reaction of a society on nuclear waste in Barents region”** is carried out under a management FOA - Swedish Defence Research Establishment and CERUM - Centre for Regional Science of the University of Umea (Sweden) at participation UAF - University of Alaska, Fairbanks, KNC - Kola Centre of Science of Russian Academy Science (RAN), MMBI - Murmansk Sea Bbiological Institute KNC of RAN. A component of the program is the project INTAS 96-1802 **“An Estimation of potential risk of radioactive pollution of an environment on Europe from nuclear sources on Russia”.** This project (scientific official responsible for the project - Dr. **R. Bergman**) consists of 5 directions and is carried out by forces Swedish Defence Research Establishment (Sweden) - direction 1, Oulu University (Finland) - direction 2, Institute of applied Mathematicians of RAN (Russia) - direction 3, Laboratory of Modeling of an Environment of KNC of RAN (Russia) - direction 4 and St.-Petersburg State Technical University (Russia) - direction 5 (scientific official responsible for this part of the project - Dr. **I. Lisovsky**). The main aims of this part of INTAS project are:

- Description of source-term characteristics for accident or leakage scenarios involving airborne radioactive release:
  - a nuclear submarine moored in a fjord on the Kola Peninsula;
  - a facility for storage of spent nuclear fuel;
  - a facility for storage of solid radioactive waste.
- Description of source-term characteristics for accident or leakage scenarios involving radioactive release to soil or aquatic recipients.
- Estimations of the potential radioecological damage.
- Participation in creation of the data base of the nuclear risk objects.

In researches on a direction 5 projects INTAS participate the experts from St.-Petersburg State Technical University, Research Institute of Industrial and Marine Medicine, Krylov Shipbuilding Research Institute, other research and design organizations of Ministry of Defence of Russia.

Problems of researches of this INTAS project, correspond to the purposes of the Research High-Technology programme on the problems of nuclear waste (HTP), carried out under the direction of State committee on problems of North of Russian Federation (the Chairman - Mr. **V.Goman**) and are directed on development of uniform coordinated policy on radiaton safety on North of Russia.

During operation and repairs of the ships with NPP probability of occurrence nuclear and radiation failures, classified as hypotetical is not excluded. At these failures are possible significant radioactivity releases. Storing and the transport of the nuclear weapon also causes an opportunity of failures with heavy radioecological consequences.

From the list of typical emergencies, possible on various operation phases and service of the ships with NPP, for development of the scripts of failures with the purpose of further determination of their possible radioecological consequences, basic failures, submitted in table 2, were allocated.

At an estimation of influence emergency ejections and discharges on the population and environment the most conservative assumptions concerning the script of development of failure, quantitative and nuclides structure of ejections and discharges, character of distribution of radioactivity in atmosphere and water environment, conditions exposure of the separate person were accepted.

Table 2
The list basic design and hypotetical of failures for description of the scripts of their development

NN	Accident	Possible reasons (basic)	Class of accident
1	2	3	4
1	Discharge of liquid radioactive waste in water area at reception (transfer) on special vessel	Infringement of technological process, error of the personnel, adverse weather conditions	Project accident
2	Submergence in water areaship-repairing factories prepared to transportation the reactor block cut out at the decommissioning	Infringement of technological process, non-observance of rules of safety, error of the personnel	Project accident
3	Ignition (local fire) in reactor compartment at the decommissioning of the ship	Infringement of technological process at transportation, errors of the personnel, adverse weather conditions, navigating failures	Maximum project accident on the factory
4	Failure with loss of heat transfer on the ship with NPP	Refusal of means, error of the personnel	Maximum project accident on the ship
5	Submergence of the ship with an active zone in water area of item of basing	Navigating failure, extreme weather conditions, error of the personnel, terror	Hypotetical accident
6	Destruction of the storage of the liquid radioactive waste	Terror, fall of the flying apparatus, extreme natural situations	Hypotetical failure with greatest possible discharge in water area
7	Fire (general fire) at the decommissioning of the ships with NPP	Infringement of technological process, infringement of rules of safety, error of the personnel	Hypotetical accident
8	Spontaneous chain reaction on the ship with NPP	Infringement of technological process at reloading of an active zone, error of the personnel, terror	Hypotetical accident (maximum possible accident)

On the basis of data, submitted in the report about the first stage of INTAS project 96 (12)**,** scripts of the basic possible failures on naval objects with maximum radiological consequences are described.

The fulfilment of the project provides necessity of the decision of the basic problem - estimation of risk of transboundary radioactive pollution at nuclear and radiation failures in Kola-Barents region of Russia.

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