Some Points in Legal Regulation of Radioactive Waste Management

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Gosatomnadzor of Russia is guided in its activity by a conception, that the national legislation is one of the most important elements in the system of nuclear and radiological safety of the country. The regulatory legal documents of Russian Federation regulating radioactive waste management represent a hierarchical structure. The contents of the documents depends on their place in the above hierarchical structure: so, the documents related to the top levels contain legal provisions of a more general character and give effect to the lower-level documents. The documents of the lower levels, after being co-ordinated with the higher level documents, deal with concrete practical problems to a much greater extent.
At present, the system of the legal acts regulating radioactive waste management, is at the stage of development. Some acts were accepted and put into force, others are at the stage of elaboration or confirmation. The elaboration of the federal norms and regulations in the sphere of the use of atomic energy is one of the lines in the activity of the Scientific and Technical Centre of Gosatomnadzor of Russian Federation. In the development of regulatory technical documents regulating radioactive waste management, Gosatomnadzor of Russia and its Scientific and Technical Centre are guided by the provisions of the national law and recommendations of international competent organizations, such as International Agency for Atomic Energy and International Commission for Radiological Protection.

Further, I would like to describe in more detail the work carried out within the period August 1997 - September, 1998. Within that period Gosatomnadzor of Russia was proceeding with the work on the Federal Program of radioactive waste management. The role of the Scientific and Technical Centre of Gosatomnadzor of Russia in the above program consisted in the development of the legal documents regulating the questions of radioactive waste and spent nuclear materials' management. In 1997, the Scientific and Technical Centre, together with the 3-rd and 4-th Directorates of Gosatomnadzor of Russia carried out the work for optimisation of the structure and the list of the regulatory legal documents regulating safe management of radioactive wastes. The experts from other organizations (apart from Scientific and Technical Centre and Gosatomnadzor of Russia) were involved in the work (Minatom of Russia, Goscomecology of Russia, FUMB&EP of the Ministry of Public Health (Minzdrav) of Russia, research institutes VNIIPIET, VNIIPPT named after Bochvar, State Research Centre «Institute of Biophysics», ÌÊC "NUCLIDE", MosNPO" Radon " etc.)

The works were carried out under the following two basic directions:
1. Completion of the conception and formation of the system of the regulatory documents regulating safe radioactive waste management.
2. Elaboration of the new documents and completion of the draft regulatory documents meant for regulation of safe management of radioactive wastes and spent nuclear materials.

Results of the work carried out under the first direction

The regulatory legal document "Conception of Formation of the Regulatory Document System Regulating Safe Radioactive Waste Management" was produced and co-ordinated with Minzdrav of Russia, Minatom of Russia and Goscomecology of Russia.
The above document was approved by the Decree of Gosatomnadzor of Russia from November 5, 1997 # 8 and the Decree of the Ministry of Public Health of Russia from January 15, 1998 # 2 and was put into effect beginning with July 1, 1998. The document was published in the magazine "Atomic Energy" (volume 84, edition 4 - April, 1998). In the course of the work with the conception of the regulatory legal documentation system, all the basic materials related to radioactive wastes (national and international legal acts, regulatory technical documents, recommendation of IAEA and ICRP) were analysed. Special attention was given to the RADWASS regulations on radioactive waste management, developed under the IAEA guidance since 1991. As a consequence of the fulfilled work, it is possible to develop the regulations covering all the aspects of safe radioactive waste management and consisting of 22 regulatory documents, including: 10 regulatory documents containing federal norms and regulations in the field of the use of atomic energy and 12 instructions on nuclear and radiation safety. (For comparison - the RADWASS system developed by IAEA contains 55 documents, including the following: 1) Basics of safety -1; 2) Standards of safety - 6; 3) Instructions on safety - 28; 4) Methodical instructions -20.)

As a result of the work fulfilled under the second direction, the following regulatory legal documents were approved in 1997 and put into force on July 1, 1998, by the decrees of Gosatomnadzor of Russia:

- "Safety Rules in Radioactive Waste Management of Nuclear Stations. " The Decree of Gosatomnadzor of Russia from September 29, 1997 # 7; PNAE G-14-41-97 (volume 84, ed. 1, January, 1998 was published in the magazine "Atomic Energy ".)
- "Water-chemical Mode at Nuclear Stations. Safety Requirements. " The Decree of Gosatomnadzor of Russia from December 8, 1997 # 11; RB G-12-43-97.

The following regulatory documents are now at the stage of completion and preparation for approval and publication:

- "Safety Rules in Removal of Industrial Reactors from Service" - the final wording of the document was developed and evaluated positively by the Minzdrav and Minatom of Russia. The document has been submitted for publication in the official press.
- "The Requirements to Quality Ensuring Program for Radioactive Waste Management" - the final wording of the document was developed and supplied with positive comments of the interested organizations. The document was reviewed at the Working commission of Gosatomnadzor of Russia on June 9, 1998. It was recommended to submit the document for final approval, upon some adjustments.
- "Burial of Radioactive Wastes. Principles, Criteria and Basic Safety Requirements." - the final wording of the document was developed and supplied with positive comments from the interested organizations. The document will be put into effect within 6 months.
- «Processing of Spent Nuclear Fuel. Safety Requirements.» - the final wording of the document was developed and evaluated positively by the interested organizations. The document will be reviewed in 1998 at a Working commission of Gosatomnadzor of Russia.
- "Safety Rules in Transportation of Radioactive Materials"- the final wording of the document was developed and got positive evaluation of the interested organizations. The document was reviewed at the Working commission of Gosatomnadzor of Russia in December, 1997. Upon examination of the document it was suggested to continue its elaboration in the form of two separate documents:

1) "Safety Rules in Transportation of Radioactive Materials" - the document that would cover all the technological and organisational requirements for safe transportation of radioactive materials.
2) A regulatory legal document (to be approved by the Government of Russian Federation), that would regulate the competence split-off among the executive federal organizations responsible for atomic energy use management and for state regulation of safe use of the atomic energy.

According to the decision of the Board of Gosatomnadzor of Russia (August 19, 1997), the Scientific and Technical Centre, together with the 1-st, 3-rd and 4-th Management's of Gosatomnadzor of Russia discussed the necessity of the development of the spent nuclear materials' nomenclature subject to safety regulation, as well as the need of preparation of the appropriate regulatory documents concerning their management. As a result of the work, it was stated, that no need to develop the nomenclature of spent nuclear materials, or to produce any special regulatory documents for their management, exists.

The Scientific and Technical Centre, together with Gosatomnadzor Management's are engaged in the work for preparation to join the requirements of the "United Convention on Safe Management of Spent Nuclear Fuel and Radioactive Wastes " (September 29, 1997). This work is carried out in accordance with the decision of the Board of Gosatomnadzor of Russia from February 24, 1998. In order to provide the most complete picture of the system of regulatory documents under development covering all the aspects of radioactive waste management the most detailed attention was given to all the important and actual issues related to this problem, in addition to those directly related to the development of the regulatory documents.

Such approach to the problem allowed to prepare and publish in 1997 two more reports (in addition to the planned ones):
1. "International Legal Regulation of the Problems Related to Safe Radioactive Waste Management" (Authors: R.B.Sharafutdinov, A.B.Choporniak, S.G. Tchukhin)
2. "Cost Parameters of the Processing and Burial of Low-, Medium-, and High-level Radioactive Wastes in the Leading Foreign Countries." (Authors: R.B.Sharafutdinov, V.A.Neretin)

In 1997, the report covering the research work «Participation in the Federal Program on Radioactive Waste and Spent Nuclear Materials' Management, Utilisation and Burial in 1996-2005» (Authors: R.B.Sharafutdinov, A.A.Stroganov) was published and distributed to the State Customer and Gosatomnadzor Management's for better familiarisation with the results of the work carried out under the above Program. The discussion of the working plans took place at the meeting of the section of Scientific and Technical Council of Gosatomnadzor of Russia " Safety of Fuel Cycle Plants" held in March, 1997. There, the above reports were discussed and recommended for publication in mass media. The results of the work were reported at the All-Russian Conference "Safety Regulations in Radioactive Waste Burial" (Comment: The meeting was organised by: MosNPO "Radon" - Gosatomnadzor of Russia, on June 2-5, 1998). The above results were also discussed at the sessions of the Interdepartmental Co-ordination Council for federal program management at Minatom of Russia.

It was mentioned above, that the document "Burial of Radioactive Wastes. Principles, Criteria and Basic Safety Requirements" is now at the stage of finishing and preparation for

publication. I would like to describe this document in more detail. This document is of principal importance. Therefore, I will give here some of the provisions which constitute its basic structure.

The document consists of five sections and is composed, as follows:
1. Purpose and sphere of application of the document.
2. The purpose of radioactive waste burial. Principles and criteria of ensuring the safety of radioactive waste storage facilities.
3. General requirements for ensuring safe radioactive waste storage.
4. Basic safety requirements in design and location of radioactive waste repositories.
5. Basic safety requirements for construction, commissioning, operation, removal from operation and closure of radioactive waste repositories.

On main principles and criteria of ensuring safe radioactive waste storage facilities
The main principles of safe radioactive waste burial are the following:
1. Protection of the health of personnel and population.
2. Protection of natural environment.
3. Protection of the future generations.
4. Non-burdening the future generations with excess responsibility.
5. Graded safeguard.
6. Safety of the repository after closing, irrespective of further monitoring. ("Safety of radioactive waste repository, irrespective of monitoring support)
7. Optimisation principle.

The «Safety Requirements ...» establish the infrastructure of safety criteria for different types of activity in the sphere of radioactive waste management.
1. For all the stages of radioactive waste management, including the final burial (except for the period upon termination of the established administrative monitoring after closing the repository) safety criteria for population and personnel are set up. They are absolutely similar to those, established by current legislation for any other types of radiological hazardous objects.
2. A combined (hybrid) safety criterion is suggested for estimation of long-term safety of radioactive waste repository systems, for the period upon termination of the established administrative monitoring after closing the repository.

   2.1. For normal radiation exposure a dose criterion is accepted .
   The individual dozes of normal radioactive irradiation of population from radioactive waste repository should not exceed the corresponding limiting values of the dose, established by federal norms and regulations for now-living generations (with due regard for the quota for a unit source).

   2.2. For potential radiation exposure a risk criterion is accepted:
   The values of the individual risk connected with potential risk of irradiation of population in the case of unlikely (low probability) accidents, should not exceed the potential exposure risk limits established by federal norms and regulations for the now-living generations (with due regard for the quota for a unit source).
   (Comment: The quota = 0,1)

2.3. Criteria for ensuring safety of radioactive waste repositories at different stages of their service life cycle.

2.3.1. The radioactive waste storage facility meets the requirements of safety in the period of its commissioning, operation, removal from service and closing, if its irradiation effect on the personnel, population and environment, under normal operation, infringements of normal operation, including the accidents within the design basis, does not lead to excess dozes of exposure for personnel and population, increased releases and effluents, (as compared to the norms), increased contents of radioactive substances in the environment, and is limited in the case of the accidents beyond the design basis.

2.3.2. Safe exposure doze limits for personnel and safe exposure doze limits for population, and if necessary, the limits of allowable emissions and releases into the environment and the contents of radioactive substances in the environment are established according to the federal laws and federal norms and regulations on radiological safety both for normal operation, and for accidents. The exposure levels of irradiation of the personnel working at the radioactive waste repository and of the population in the result of emissions or releases of radioactive substances of any type from radioactive waste repositories should be lower than the established limiting values and stay at a reasonably acceptable low level.

2.3.3. In normal operation of radioactive waste repository and in the case of any infringements of its normal operation, including the accidents within design basis:

- the effective (not all body) and equivalent dozes (for separate organs) of irradiation of the personnel should not exceed the radiation safety doze limits established by the current radiation safety norms for the personnel $DP_{pers.}$;
- the effective (not all body) and equivalent dozes (for separate organs) of irradiation of the population in the form of effluents and releases of radioactive substances from the repository at the boundary of sanitary-protective zone and beyond its limits, should not exceed the values $DP_{pop.} \times h$, where $DP_{pop.}$ - is the value of radiation safety doze limits established by the existing radiation safety norms for the population and h -is the quota of the annual exposure doze of the population;
- established for the repository by a safety regulatory body; the values of emissions and releases of radioactive substances from the repository, and also the contents of radioactive substances in the components of the environment should not exceed the norms established for the repositories by the federal bodies responsible for safety regulation, i.e. -allowable emissions and releases and allowable contents;
- the value of the collective radiation dose of the population and personnel should be as minimal as possible, with the given economic costs.

2.3.4. For the accidents beyond the design basis at radioactive waste repository:

- The value $R_{a.b.d.b.}$ -i.e. the probability of occurrence of an accident beyond the design basis should not exceed the allowable values $R_{a.b.d.b.}$-add, established by the existing regulatory documents for the accidents beyond the design basis at nuclear plants, radioactive sources and repositories;
- the values of radiation doses for the personnel during the occurrence and in the process of accidents, if they cannot be avoided, are not regulated;
- the expected values of radiation dozes for personnel during liquidation of the consequences of an accident, should not exceed the allowable limits established by the federal bodies responsible for safety regulations in the case of expected excess irradiation;

- the measures of protection of the population (counter-radiation measures) in the case of occurrence of an accident beyond the design basis at a radioactive waste repository, as well as the instrumental facilities and monitoring regulations of occurrence of the accidents beyond the design basis should guarantee the application of specified counter-radiation measures at the earliest stage of the accident, but in all cases -before irradiation of the population living within the limits of the zone where the planned protective measures should apply, with the effective radiation dozes (for corresponding periods of time before the occurrence of an accident), exceeding the minimal values established (for the site of location of the particular radioactive waste repository) by safety regulation bodies and the values established by the existing norms of radiation safety (for all country) and the values of predicted effective radiation dozes at which the counter-radiation measures would be certainly necessary;
- effective (for all body) and equivalent (for particular organs) radiation dozes for the population at the boundary and outside the zone where the planned protective measures should apply, shall not exceed the values $DP_{pop.} \times h$;
- the contents of radioactive substances in the environment at the boundary and outside the zone where protective measures should apply, shall not exceed the normal values established for radioactive waste repository by the safety regulation body- i.e. allowable emissions and releases and allowable contents.

2.3.5. The radioactive waste repository meets safety requirements if in the period from its closing and up to the time of expiration of the designed period of monitoring, its radiating effect on the personnel, population and environment under normal (most probable) evolution of the radioactive waste repository, when radionuclides behaviour and release from the repository is governed by the processes envisaged in the project as basic (normal), with due regard for admissible deviations allowed by design through some uncertainty in the meanings of protective barriers' characteristics and some changes in the characteristics with the time:

- the radiation doses for the personnel carrying out routine operations according to the program of the planned active monitoring, should not exceed the radiation doze limits established by the existing radiation safety norms for the personnel -$DP_{pers.}$;
- the effective (for all body) and the equivalent (for particular organs) dozes of irradiation with nuclides from the repository, of the population living and working (any work, including well drilling, etc.) at the boundary and outside the zone of monitoring, should not exceed the values $DP_{pop.} \times h$;
- the values of emissions and releases of radioactive substances from repositories should not exceed the meanings established for the repository by the federal body responsible for safety regulation - i.e. allowable emissions and releases, while the contents of radioactive substances in the environment at the boundary and outside the zone of monitoring shall not exceed the value of the established allowable contents;

2.3.6. The radioactive waste repository meets the requirements of safety if in the period from its closing and up to the time of expiration of the designed period of monitoring, its radiating effect on the personnel, population and environment under normal (most probable) evolution of the radioactive waste repository, when radionuclides behaviour and release from the repository is governed by the processes envisaged by the project as basic (normal), with due regard for admissible deviations allowed by design through some uncertainty in the meanings of protective barriers' characteristics and some changes in the characteristics with the time:

- the effective (for all body) and the equivalent (for particular organs) dozes of irradiation with the emissions and releases from the repository, of the population living and working (any work, including well drilling, etc.) everywhere beyond the boundaries of the former repository site, should not exceed the values $DP_{pop.} \times h$;
- the effective (for all body) and the equivalent (for particular organs) dozes of irradiation with the emissions and releases from the repository, of the population living and working in the sphere of agriculture, everywhere within the limits of the repository site (including the former site) should not exceed the values $DP_{pop.} \times h$;
- the additional radiation risk for critical groups of the population due to their economic activity, other, than usual agricultural activity (e.g., connected with well drilling of etc.) within the limits of the former repository site should not exceed the meanings $PR_{pop.} \times h$, where $PR_{pop.}$ is the potential radiation risk limit established by radiation safety norms for the population; for near-surface repositories (see item 3.5) the potential dozes of irradiation of the population should be additionally limited with the determined irradiation effect threshold;
- the values of emissions and releases of radioactive substances from repository should not exceed the meanings established for the repository by the federal body responsible for safety regulations of the norms - i.e. allowable emissions and releases, while the contents of radioactive substances in the environment everywhere in the area of location of the repository and beyond its limits should not exceed the established allowable contents;
- the value of collective doze of irradiation of the population should be as minimal as possible with the given economic costs.

2.3.7. The radioactive waste repository meets safety requirements in the case of unlikely (low probability) destructive events of natural or technical origin in the zone of potential radioactive impact from the repository, before the expiration of the period of monitoring stated in the project;

- the probability of occurrence of the specified destructive events should not exceed the allowable values established by the existing regulatory documents for the accidents beyond the design basis at nuclear stations;
- the dozes of irradiation of the personnel in the process of occurrence and development of the destructive event through radionuclides release from the repository, (if irradiation cannot be avoided,) are not regulated;
- the expected values of radiation dozes during liquidation of the effects of the destructive events should not exceed the allowable limits established by the federal bodies responsible for safety regulations in the case of expected excess irradiation;
- the effective (for all body) and the equivalent (for particular organs) dozes of irradiation (in the result of emissions and releases from the repository during accidents), of the population living and performing any type of economic activity at the boundary and outside the zone of monitoring, should not exceed the values of the effective annual radiation dozes equal to the minimal values out of those established by the existing radiation safety norms as criteria for necessary application of counter-radiation measures.

2.3.8. The radioactive waste repository meets the requirements of safety in the case of unlikely (low probability) destructive events of natural or technical origin in the zone of potential radiation impact from the repository after the expiration of the monitoring period stated in the project, if the risk of irradiation (connected with irradiation during accidents,)

of the population living in the zone of potential radiation impact from the repository, should not exceed the values $PR_{pop.} \times h$, where $PR_{pop.}$ is the value of potential radiation risk established by the norms of radiation safety for the population; while for near-surface radioactive waste repositories (see item 3.5) the potential dozes of irradiation of the population shall be additionally limited with the value of determined irradiation effect threshold.

Implementation of the conception of graded safeguard of radioactive waste repository

The safety of radioactive waste repository should be ensured by means of gradual implementation of the conception of graded safeguard throughout the entire period of burial of the radioactive wastes representing potential hazard for the people and for the environment. The conception of graded safeguard is based on the application of the following components:

- a system of series of independent barriers on the way of ionising radiation and emission of radioactive substances into the environment;
- technical and organisational measures for protection of the barriers and preservation of their efficient condition.

The conception of safe radioactive waste repository implies the use of some elements of the geological environment (embedding soils) as one or several physical safety barriers in addition to the engineering safety barriers. Generally, the system of protective barriers of radioactive waste repository consists of the following components:

- Physical /chemical form of radioactive wastes;
- Walls of the container;
- Biological protection;
- Buffer materials;
- Tight protections;
- Engineering constructions;
- Materials used in the process of closing of the repository;
- Covering and underlying screens (for near-surface type of repositories);
- Embedding soils or rocks.

The system of technical and organisational measures should include, generally, the following 4 levels of graded safeguard:

Level 1	- prevention of the infringements in normal operation of the repository;
Level 2	- prevention of the accidents within the design basis;
Level 3	- planned counter - accident measures - adjusting interference - management of accident;
Level 4	- planned counter - accident measures - adjusting interference for protection of the personnel, population and the environment.

In so doing (generally) the priority should be given to the strategy of prevention of adverse events, especially at the levels 1 and 2.

Service life cycle of the repository

The service life cycle of the repository can be subdivided into the following stages:

I stage	- selection of the site and planning of a repository;
II stage	- construction of a repository;
III stage	- commissioning of a repository;
IV stage	- maintenance (operation) of a repository;
V stage	- removal of a repository from service (operation) and its closing;

VI stage - post-operation monitoring of a repository;
VII stage - post-operation decontrolled state of a repository;

Further on, the report will provide some items related to the 1-st stage of the repository service life cycle and discussed in this document. The 1-st stage includes the selection of the site for location of the repository. The document states a number of provisions regulating this procedure. The document outlines the factors, which should be taken into account when selecting the site. The following factors should be considered when evaluating a suitable site for placing the repository: the environmental, economic, social, demographic etc. I would like to dwell on the geological factors which are really important for safety of the repository. As mentioned above, the geological environment is considered as one of the safety barriers. It should be noted, that the role of geological environment would be different for the repositories of different types. So, for deep repositories (hundreds of meters) the geological environment plays the role of the main safety barrier. For near-surface repositories the geological environment fulfils a number of safety functions:

1) serves as a reserve safety barrier in the case of probable occurrence at the repository of the accidents beyond the design basis;
2) protects engineering safety barriers from the adverse impact of natural and technical-related character, typical for the given region.

The function of a reserve safety barrier does not reduce the requirements to the geological conditions at the site of location of the repository. Since geological environment serves as a safety barrier, rigid requirements are applied to the rock mass, where the repository will be placed. This also concerns the quality of the prospecting works, which should provide the data for selection of the site. In estimation of the suitability of the site for location of the repository the geological structure in the area of construction as a whole, and at the site in particular, should be studied in detail. That is, both the regional, and the local geological factors should be investigated. The study of the geological structure implies the performance of complex prospecting works. As a result of the above prospecting works, the following data should be received:

- Structural- tectonic data,
- Stratographic data,
- The data on geological history of the region,
- Petrographic (lithologic) data,
- Mineralogical data,
- Geochemical data,
- Hydro-geological data,
- Engineering-geological data,
- The data on the current physical-geological processes and phenomena in the area,
- Geomorphological data,
- The data on the current movements of the earth's crust,
- The data on seismicity of the area.

The obtained data are used to predict the possible effects of geological processes on the repository. The forecast covering opposite processes should also be made: i.e. the forecast of the changes in geological conditions and geological processes under the effect of the repository operation. The geological environment serves not only as a safety barrier. Geological properties (i.e. geological conditions) also serve for the selection of the optimal (for the given site) type of engineering structures for construction of the repository. Multiple factors affecting

the selection of the site for location of the repository show that the site for construction of radioactive waste repository should be selected on the basis of several comparable alternative variants. "The Requirements ... " also include the following provisions:

- at all the stages of the repository service life cycle the quality control of the fulfilled works should be carried out,
- the report justifying the repository safety should contain, among other things, the estimation of reliability of the used data.

The results of geological works can be considered reliable and qualitative, if the works were carried out, as follows:

- with the observance of geologic research methods confirmed by corresponding norms and rules, (the sequence of geological works should be observed; scale of research operations should correspond to the set task; proper account of the former research experience to be made, field and laboratory research methods to be applied, density of observation network to be observed);
- combining various research methods, (i.e. the combination of geological, hydro-geological, geophysical and other methods);
- with application of field and laboratory methods of research.

The data used as geological justification of the correct selection of the site should be confirmed by the results of the observations carried out by different methods. Accordingly, the report on justification of the repository safety should contain the quality assessment of the geological studies and geological data used for selection of the site.

The language of the document is laconic, therefore, I would like to illustrate the above provisions by some geological examples and show how these provisions are applied in practice. In our country the possibility to locate radioactive waste repositories in permafrost zones (e.g., on the islands of Novozemelsky archipelago) is considered. Such proposal is evident by the following reasons:

- the permafrost area in the territory of the former USSR amounts to 47%;
- permafrost soils, such as clay or saline soils, have low water permeability.

This factor is very important, because the underground waters are the main radionuclides transporting agent in the case of failure of leak-tightness of the repository. Probably, low water permeability of permafrost rocks was the main reason why such suggestion was made. It is true that in the process of freezing the water-bearing beds of the rocks become waterproof, that is, transform into a cryogenic water confining stratum. The reverse process takes place during melting- the cryogenic water confining stratum again turns into a water-bearing horizon. One of the features typical for cryogenic water confining stratum (which can again turn into a water-bearing horizon) is large contents of ice in the rock. However, besides the water in its solid state, the permafrost rock mass contains water in its usual, liquid state. The following types of underground waters can be identified in permafrost areas:

- the waters located above permafrost (melt-water layers of seasonal character and non-through taliks);
- seasonal melt-waters are widespread everywhere;
- the waters in between the permafrost layers -interpermafrost waters (water in the non-frozen and thawed layers limited from above and from below with permafrost zones, such waters are usually connected with other categories of underground waters) and the

intrapermafrost waters (waters contained in the layers and lenses, limited from all sides by permafrost zones, these waters have no water exchange with other categories of underground waters); interpermafrost and intrapermafrost waters are subdivided into two groups:

a) saline waters and salt brines with negative temperature - cryopegs,
b) slightly-mineralised waters with positive temperature.

- waters under permafrost- the water arriving from the closest to the permafrost sole water-bearing horizon, complex or jointly zone (such waters are subdivided into contacting and non-contacting waters located under permafrost zone, and non-contacting deep waters);
- through taliks.

Hence it follows that even if the site is situated in the permafrost zone a detailed hydro-geological study both of the site, and of the entire area would be necessary. It is also clear, that the contents of ice in the massif should be identified. (Comment: Comprehensive geological study should be carried out to identify a rock massif containing no underground waters, or to prove that the lenses and horizons present in the massif are not dangerous for the repository. Ice contents in the rock massif should be identified. The rocks with negative temperature, not containing ice- the so called frozen rocks, would be preferable).

It is impossible to make the conclusion about the suitability of the massif for construction of the repository if we have no data on hydro-geology and ice contents of the massif. (Comment: The more porous and fractured the rock, the greater is its water permeability. Accordingly, the greater ice contents is typical for porous and fractured rocks).

Special studies should be carried out in permafrost areas. The studies should be regulated by the appropriate federal norms and rules (SNIPs, GOSTs, methodical instructions of MinGeo and GosStroy). The application of corresponding norms and rules should be justified. In particular, the following special research studies should be carried out in the territory of the cryolite zone: temperature logging and permafrost survey.

Thermal logging.
Thermal logging would be necessary, since the permafrost temperature is different at different depths, and each of the temperature layers has own thermodynamic characteristics. The importance of the thermal data collected at different depths grows with the extension of the observation period. The data is most valuable when obtained during multiyear survey with given periodicity (e.g. every ten days). [In particular, such periodicity is typical for the observations carried out in special observation wells located in the vicinity of important technical objects. The observations allow to reveal the changes in permafrost temperature mode, as a result of heat release from the object].

Long-term temperature measurements allow to reveal the changes in the temperature mode of permafrost rocks, as a result of climate changes. So, at abnormally high summer temperatures the thickness of seasonal melt-water layer sharply increases. The thickness of permafrost rocks also depends on global climatic fluctuations (with short periods and long periods). Besides the annual (seasonal) temperature fluctuations, we observe other periodical fluctuations of temperature: every 11 years, approximately every 40 years, 300 years, thousands, tens of thousands, hundreds thousand years. The shorter the period of fluctuation, the smaller is the depth at which the fluctuation is damped. Temperature fluctuations with long periods affect the

aggregate thickness of the permafrost layer (aggradation - degradation), while the fluctuations with short periods affect the thickness of upper temperature horizons of the permafrost. With global climate cooling the thickness of permafrost stratum is growing (aggradation process), with global climate warming -it is decreasing (degradation process). Therefore, it is necessary to have complete information about the tendencies of global climate changes in the investigated area, when planning the construction of radioactive waste repositories. It is also necessary to evaluate the rates of warming/cooling processes, and after that - the rates of decrease / increase of the permafrost stratum thickness. [At present, the global climate warming in the result of technical activity of a man has become a reality. Usually this statement is not disputed. On this basis we can predict the reduction of both the total area of permafrost rocks, and their thickness. The problem consists in the evaluation of the rates of permafrost reduction process.] The vertical periodic fluctuation of the upper and lower zero isotherms affects the state of the rocks interposed in between these intervals. The frost/thaw processes are repeated in the geological history of the region, and at these intervals the rocks acquire increased jointing, and consequently- higher permeability and lesser strength. (This process is determined by the term " cryogenic disintegration of rocks".)

Permafrost survey

The permafrost survey is represented with the integrated field and laboratory operations aimed to study the mechanisms of composition, formation and development of permafrost layers and processes in the area. The results of permafrost survey (permafrost studies) are used for permafrost forecasting and for permafrost processes' management. Permafrost forecast is the evaluation of the changes occurring in permafrost characteristics under the influence of the changes of environmental character as a result of technical activity of a man. In this case, when deciding on the suitable site for the repository we are interested in which way the permafrost characteristics can be affected by construction and operation of the repository. For ever-frozen areas the permafrost forecast plays the primary role, serving as a basis for other types of forecasts: engineering-geological, geographical, etc.. So, without the results of permafrost survey and permafrost forecast we can not reliably evaluate the suitability of a site and the adaptability of the repository to the given conditions. It should be noted that generally the geological environment is considerably less variable than the geographical situation which includes usually a series of surface conditions. In the permafrost area the situation is quite different. Here the geological environment represented with permafrost rocks is a rather changeable component of the natural environment. Quite frequently such changes cause variations of the other components of the environmental complex, such, as relief, vegetation, micro-relief and surface deposits, swamping, flooding, etc. The changes of temperature conditions and moisture contents, especially during periodic freezing/thawing (at upper and lower zero isotherms' intervals), cause variations in rock structure and properties, their strength and bearing capacity, in the forces produced by frozen soils during soil heaving, the heaving speed and value, the permafrost settlement speed and value during thawing ("thermal settlement of rock "), thermal rock deformation, variation of filtration properties of the rocks during frost/thaw process, development of thermokarst, solifluction, and other cryogenic processes and formations.

The changes of permafrost conditions in the result of technical interference, that is, in our case, by the construction of the repository, can proceed in two ways.

1. Spontaneous and unpredictable changes, with catastrophic ill effects for engineering structures and the biosphere. It is clear, that in such case the construction of the repository in permafrost area has nosense.

2. The predicted changes thanks to application of the required measures for permafrost process management. In such case the permafrost rocks will not cease to serve a reliable safety barrier, and the adverse influence of cryologic factors on the repository will be excluded.

As it was mentioned above, " The Requirements.." read that the choice of the optimal type of engineering structures for the repository is determined by the geological conditions at the site. The construction of the engineering structures in cryolithozone is carried out according to one of the two principles:

Principle I	- the soils at the foundation are in frozen condition during the entire period of operation of the engineering structure;
Principle II	- the soils at the foundation are in thawing and thawed condition.

(Comment: Apparently, the authors recommending to bury radioactive wastes in permafrost rocks have in view the principle I.)

Therefore, the project should contain justification of the construction principle and it should be shown, that the selected principle ensures safe operation of the repository. It is also clear, that the construction principles should be different in the case of surface or deep repositories. The principles of construction should also be different for the repositories of low/ medium-level radioactive wastes and for high-level radioactive wastes. The permafrost forecast management methods will also be different for the repositories of different types. By permafrost process management we mean such effect on the elements of environmental and technical complexes, which would cause such change of permafrost conditions as necessary for the construction. In such case we can speak about guaranteed effective use of the permafrost properties. The effective use of properties here means that the rocks do not cease to keep their protective functions. (Comment: We must not rule out the possibility that the construction of surface repositories in permafrost rocks may require more elaborate engineering decisions, as compared to the construction of deep repositories. The problem consists in the infringement of configuration of the seasonal-thawed layer during stripping, e.g. during digging foundation pits and trenches. The measures ensuring restoration of permafrost conditions in the top horizons for preservation of insulating properties of permafrost rocks, would be required. It is also clear, that the permafrost properties will vary depending on the heat release from the repository, especially, from high-level radioactive waste repository. It is clear, that such effect should be taken into account and balanced. Appropriate engineering decisions should be provided for in the management of permafrost process. For the time being, there is a number of such decisions obtained in the result of construction in permafrost areas. Typically, they are limited to the regulation of the temperature of enclosing/ bearing soils. The repository design should foresee and justify the decisions related to permafrost process management. The document contains the requirement to monitor the state of safety barriers of radioactive waste repository. If the repository is located in permafrost rocks the monitoring of permafrost conditions should also be carried out. Further, the measures preventing the development of adverse processes should be forseen. The permafrost factors should guarantee such state of the object during the entire service life of the repository which completely excludes any possibility of the infringement of safe condition of the object under the effect of the above factors.
Here we have described in brief a sample analysis of the suitability of a site located in permafrost area. For the site situated in other areas, specific features of the area should be

taken into consideration. But in any case, the analysis should base on the requirements stipulated in this document.

The requirements of the document govern and determine the following procedure in the selection of a site:

- detailed study of the area;
- allocation of several (alternative) perspective sites;
- comparative analysis of the sites;
- allocation of the site with the most favourable conditions;
- additional study of the site and the analysis of geological conditions from the point of view of their impact on the safety of the repository.

Further, the obtained data are used to devise the measures for adaptation of the repository to the site conditions, and in drawing up of the report on justification of radioactive waste repository safety. The given example demonstrates practical and scientific validity of the Requirements included in the document, and we believe, that this document will play an important role in the system of safety regulation of the storage/burial of radioactive wastes.