

PRINCIPLES AND REQUIREMENTS FOR SITING OF UNDERGROUND REPOSITORIES FOR SOLIDIFIED RADIOACTIVE WASTE IN A GEOLOGICAL ENVIRONMENT

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ABSTRACT

A development and feasibility study of the requirements of the sites for underground location for a solidified radioactive waste repository is based on the general objective of waste management - to protect man and the environment from harmful effects during the period needed to minimize activity to safe levels (1).

Radioactive waste disposal into geological formations, meeting the specific requirements, provides radiation safety and excludes waste penetration into biosphere. In addition, waste disposal into the geological environment is capable of providing waste isolation in extreme situations, i.e. natural calamities, military operations, etc.

Waste disposal must be carried out within the vicinity of the places of their origination and accumulation to eliminate the necessity of transportation over long distances.

Solid and solidified waste isolation is carried out in deep repositories situated in host rock below the zone of active water exchange, and separated from it by a protective covering. The depth of waste burial depends upon the geological environment, volume, type and condition of the waste.

INTRODUCTION

During disposal of radioactive waste, the main isolation factor is the geological environment, independent of repository or storage construction. Waste solidification forms must provide maximum safety conditions.

For repository siting, an allotment is let which includes workings, disposal chambers, estranged sanitary zones, barrier protective pillars, and buffer zones.

If there is no opportunity to construct a repository for the placement of waste formations and accumulation, there must be envisaged a repository for a group of facilities.

Taking into account the fact that construction of underground repositories demands long period of time, creation of temporary sub-surface waste storage places with subsequent transfer to the permanent waste repositories is permitted.

The positions set forth above allow for time taken to solve the problems connected with the isolation of waste from all facilities and industry branches for a long time and must provide for:

- Technological processes on management of the waste formed at different facilities. The processes must be periodically revised according to scientific and technical achievements.
- Development of scientific research work providing a maximum level of safety.
- Normative documents.
- Practical and technological measures.

The opportunity for waste repository creation is defined by a number of criteria based on the acceptability of the following decisions:

Geological acceptability criteria define the conditions of specific sites for the location of complex workings, protective pillars, buffer zones and for the containment of materials being disposed of in the boundaries of sanitary

estranged zones under given structural peculiarities of the site, rock permeability and hydrogeological activity.

Constructional and technological criteria define the optimal conditions of waste disposal in geological formations taking into account all of the effects of its influence upon massive rock.

Criterion of optimal properties and the quality of disposed waste defines the conditions of possibility of waste disposal not exceeding the limited loads on massive rock.

Geographical criterion defines the conditions of safe repository existence in developing the eco-economical system.

Repository preservation criterion defines the conditions of protective functions of massive rock in limits of 3 CO under premeditated and unpremeditated effects.

Sanitary-ecological criterion defines the necessary conditions for technical decisions accomplished to achieve the necessary safety levels.

Economical criterion defines the optimal capital investments, taking into account the achievements concerning environmental safety problems and advantages received from prevention of accidents and thanks for socio-economical development of the region.

Practical and legal (judicial) criterion defines certain conditions, guarantees and measures the prevention of accidental repository seal failure in the future.

There are also requirements of geological formations and repository sites

When selecting repository sites, it is necessary to subsequently assess the acceptability of geological formation for this purpose.

The conditions defining the selection of a region for a repository siting are as follows:

- Belonging to the region of large, tectonic elements of the continental part of the earth's crust.
- Absence of seismic activity (not higher than 5 on a 12-grade scale).
- Availability of acceptable geological formation which is of sufficient thickness and extension.

The acceptable formations for solid and solidified waste are presented by rock salt, certain types of rocks, and clays.

As for the allotment for repository siting, there must be an exclusion from use forever the areas where there are mineral resources and productive groundwaters. There must not be any workings or underground constructions on the repository site. All of the boreholes drilled on the allotment territory must be mapped, sealed and designated. All of the documents must be kept with documents on the repository.

As for the topography of the repository site, there must be an even relief acceptable for surface construction of complexes and access roads.

When selecting geological formations with a salt covering, the use of sites with a complex relief is not acceptable because local overloads may initiate massive rock deformations and cause repository seal failure.

Repository sites must not be located in zones of possible flooding, natural calamities, dam breaks, etc.

The selected formation must present a unified block without tectonic disturbances and break zones.

The selected formation must be lithologically acceptable, free of displacements, faults and continuity disturbances. It is allowed the presence of tectonic faults in a distance of 2-3 sizes of the allotment.

Availability of lithological fissures is allowed, such as microfissures.

The repository must be located in a geological environment with lithological properties and thickness sufficient for isolation of the given waste type and quantity under certain loads.

Concerning thickness and extension, it must provide the space for the location of protective, repository elements.

Rock properties in the region of the repository site must be of equal physico-mechanical, thermo-physical, filtration and geochemical values. Some differences in property value are allowed, if they do not decrease mean adopted values.

When salt formations are used, salt structures must have size in the top portion of the domes not less than 1 x 1 km and depth of several kilometers.

The thickness of acceptable strata is defined by estimate and depends upon the constructional and technological scheme of disposal and the technological loads on the massive rock. Strata bedding must be close to horizontal.

Underground repositories must be located in regions with a minimal net of water horizons.

It is advisable to select the sites with limited water sources, which must be separated from covering by water-resistant pillars the thickness of which is estimated by calculation (but not less than 150-200m).

Geological formations in a zone of active water exchange must be excluded from the range of possible utilization.

The ideal variant includes those formation characteristics when the prevailing regime of mass transfer tends to diffusion.

The selected formation by its physico-mechanical properties and geochemical composition must provide reliability under thermal and physical loads occurring under operating conditions.

Maximum storage temperature must be held, taking into account the thermal and physical properties of the formation, availability of non-resistant minerals, and the occurrence of thermogradient moisture transfer processes.

Requirements of Underground Repositories

For the disposal and isolation of waste, the following may be used:

- Natural voids, cavities and caverns.
- Deep boreholes.
- Artificial reservoirs.
- Special underground facilities.
- Shafts.

Chamber configuration must provide the space for the location of the necessary volume of waste. If there is no necessity to support workings, it is not made.

To reach uniform warm distribution, free chamber space is filled with dense backfill. Backfill materials must not possess shrinkage properties. Its thermal conductivity and temperature conductivity must coincide with the same properties of the surrounding rocks. Backfill materials must not decompose or modify under waste influence.

Access workings and storage chambers must be located in such a way that they do not harmfully influence the environment and the number of channels connecting the repository with the surface must be minimal. The construction workings and sizes must provide safety during delivery and location of waste, as well as during sealing work. To increase the safety of the underground disposal operations beyond the sanitary estranged zone, preventative barriers are envisaged. Those barriers must not be presented by rocks with properties resembling the properties of the covering rock. There must be no workings in preventative pillars (barriers) except observation holes equipped and liquidated according to the project specifications.

Allowed loads on underground workings (rock pressure) are defined by the condition that none of the main repository elements (pillars, barriers, workings, supports) will be destroyed. To prevent working destruction and

deformation development of the massive rock, all of the chambers and underground workings must be backfilled.

Sanitary and ecological requirements define the provision of effective environmental safety measures according to USSR legal documents HPb-76 and OIIC-72/80.

There are requirements for the solidified wastes and package materials. Waste and package materials disposed of must meet the following requirements:

- Solid and solidified radioactive waste are subject to underground disposal in almost impermeable formations.
- Waste composition and its radionuclide content must be exactly defined and must meet technological specifications.

Chemical composition of waste must prevent the formation of harmful chemical elements and microbiological

processes in the repository. Harmful factors are as follows: Gaseous formations as a result of radiolysis, chemical reactions between disposed products and surrounding rocks, biological processes, the presence of fire and explosive or hazardous products, and the availability of moisture.

- Waste properties must not induce a change in the massive rock characteristics and must not give rise to seal failure of the selected geological site.
- Solidified waste must have lasting physical stability.
- Packaged materials and constructions should possess the mechanical strength to provide safe transportation and disposal of solidified waste.
- Package materials must not be of value in the future.
- On the whole, technical procedures must provide safe waste management.