

WASTE ACCEPTANCE CRITERIA FOR SHALLOW LAND REPOSITORIES

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ABSTRACT

The paper presents criteria developed for decision about acceptability of radioactive waste into shallow land repositories. Safety calculations completed by technical, formal and administrative requirements reflect the basic radiohygienic limit of annual individual dose commitment of $10 \mu\text{Sv/y}$. The proposed criteria respect the IAEA recommendations.

INTRODUCTION

General

Czechoslovak policy of making nuclear operational waste harmless is based on the treatment of low and intermediate level waste at Nuclear Power Plants followed by shipment of conditioned waste into regional shallow land repositories that are provided with engineered support and isolation structures.

The regional character of both repositories can be specified by the following characteristics:

- each repository serves producers from the republic whose territory it is built in (Dukovany for the Czech republic and Mochovce for the Slovak republic);
- although identical in concept they differ in their use of isolation materials (modified asphaltpropylene concrete, clay);
- the present capacity ($62\,000 \text{ m}^3$ or $44\,000 \text{ m}^3$ of space, both can be extended five times);
- fully different geological conditions (top of hill or valley, crystalline or sedimentary host rocks, hydrogeological and hydrological structures);
- waste acceptance criteria are site specific and they respect the national legislation, therefore in spite of their common approach to development, they differ in certain aspects.

Safety Approach

The safety analysis procedure of a repository in Czechoslovakia consists of several phases reflecting the repository development status: each step can be distinguished both by its structure and content.

The *starting safety report* deals with siting and the general design features of a repository. This formulates in these some basic, mostly qualitative, safety precautions laid down on a respective disposal system. The report is a base for investigation and research programs aimed at identification and quantification of all necessary design input data.

As a part of a repository design the *preliminary safety report* is prepared to quantify and technically specify all requirements of the previous stage. This document fully describes the desired level of safety and ways of reaching it during the facility construction, operation, and closure. The report is a part of the design and must be approved in licensing procedure prior to the start of facility construction.

The third step of safety analyses, the *preoperational safety report*, must then prove that the repository has been built in such a way that it fulfills all criteria stated in preliminary safety

report. Namely, that a really achieved quality of all components will guarantee the legislative limits of radiohygienic criteria for each individual of general population and of facility staff during all anticipated circumstances.

The last safety report reflects all claims stated in Legislative Act No. 67/1987, which also specifies its content. Among other basic information the two describing normal (designed) and critical (accidental) performances of repositories as well as any consequent limitations must be provided. They are expressed in the form of *waste acceptance criteria* and belong to documents that must be reported to the licensor for obtaining approval of a temporary start of the repository operation.

It is also expected that safety reports will be revised regularly in some five year periods according to the actual characteristics of the disposed waste. In any case the *final safety report* will evaluate the level of safety of the whole disposal structure after its closure.

The Philosophy of Development of the Terms and Limits of Repository Operation

The limits and conditions of repository operation ensure safe exploration of a repository. They are proposed in order to define normal technical functionality of a nuclear facility and to specify waste acceptance criteria.

A method of safety criteria development is described below, technical criteria were fixed mainly by producers of appliances, while administrative criteria respect other requirements based on IAEA recommendations.

The concrete procedure of development of safety criteria follows the next steps:

1. Analysis of normal operation scenarios suppose that main isolation barrier keep designed functionality till the end of institutional control period (approx. 300 y).
2. In the next stage an analysis of accident scenarios during repository operation provides basic data for determination of quantitative values of criteria parameters. The following cases are taken into account:
 - a. full vault fire;
 - b. transportation accident;
 - c. dropping of a package;
 - d. burning of transportation vehicle;
 - e. repository barrier accident with consequent release of contaminated water into soil, transportation to a surface source and via food chains to the organism of a critical person.

All but the last of these accident scenarios should document that all proposed measures and technical

precautions ensure an adequate level of personnel safety. The remaining one limits repository operation and it is directly expressed in the form of a criterium of maximum permissible mobile activity in repository vaults.

3. Other limitations are established by the evaluation of scenarios characterizing all the possibilities of population exposure after the disposal site is released for unrestricted use. As a result, activity inventory limits are laid down.

TERMS AND LIMITS OF THE DUKOVANY REPOSITORY OPERATION

It was mentioned in previous chapter that both built repositories are of the same concept, but with certain variations. As the Dukovany facility has been already licensed we prefer to focus on a description of its conditions of operation.

The goal for establishment of terms and limits of a repository operation is to distinguish between normal and abnormal situations and identify a border beyond which special precautions should be and corrective actions must be adopted so that the desired level of radiohygienic safety is assured. For that purpose a basic scheme of activities is required as well as conditions for implementation of the effective control and supervision systems.

For simplicity, all activities at the repository are divided into four operational regimes characterized by exact and clear sequence of steps. Each criterion addresses one or more particular regimes and, when broken, the regime that must then be respected. The regimes are as follows:

1. Waste acceptance and placement into vaults;
2. Open vault covered by movable shelter;
3. Final closure and covering of a vault;
4. Repository conditions controlled by specific prescriptions (e.g. accident regulations);

All accepted limits and terms of operation of the Dukovany repository are summarized in Table I.

WASTE ACCEPTANCE CRITERIA

All limits and terms of operation (see Table I) can be subdivided into five groups:

- a. conditions of repository operation (No. 1 - 4);
- b. safety parameters (No. 6 - 12);
- c. technical parameters (No. 5, 18 - 20);
- d. formal requirements (No. 13 - 17);
- e. administrative measures (No. 21 - 22).

Although only group b) is based on safety calculations, the groups c,d,e) also belong to the waste acceptance criteria.

Data about values of some waste acceptance criteria are summarized in Table II.

Safety Parameters

All safety calculations were based on target values of dose commitment for any individual or group of population. Those values were set on $10 \mu\text{Sv/y}$ and 1 manSv/y .

For definition of limits two types of scenarios were found to be critical: accidental release of contaminated water from the repository structures and scenarios quantifying the consequences of unrestricted use of the repository site.

TABLE I
Summary of Limits and Terms for Operation of Dukovany Shallow Land Repository

Criterion	Regime	Move to Regime
01. Meteorology	1	2
02. Presence of water in vault	1,2,3	4
03. Drained water	1,2,3	4
04. Functionability of appliances	1,3	2
05. Damaged final waste form	1	R
06. Mobile activity limit	1	3
07. Permissible content of radionuclides	1	R
08. Radionuclide inventory	1	3
09. Surface dose rate of the waste package	1	R
10. Surface contamination of the package	1	R
11. Leachability	1	R
12. Compressive strength	1	R
13. Free liquids	1	R
14. Waste form integrity and stability	1	R
15. Pyrophoric materials	1	R
16. Toxic materials	1	R
17. Explosives	1	R
18. Loose waste form	1	R
19. Lump waste form	1	R
20. Weight of waste package	1	R
21. Waste identification passport	1	R
22. Waste labelling	1	R
Notes: 1 - normal operation 2 - operation interrupted, vault covered by shelter 3 - final closure of a vault		

The former is expressed as a criterion of "maximum permissible mobile activity". Its value corresponds to the activity which is allowed to penetrate repository barriers without exceeding the target values of population dose commitment.

The later limits the content of radioactive isotopes in a final waste form as well as the repository inventory.

The other safety precautions provide some background information to fulfill previous criteria.

The philosophy of definition of permissible mobile activity (PMA) leads to another interesting result. After the decline of the total activity bellow PMA value due to the decay of radioisotopes no monitoring of underground waters is necessary as the system's safety is definitely assured. It was calculated that exhaustion of the waste inventory limits calls for some 80 - 90 years of monitoring which is the probable lifetime of specially adopted water wells. Actually, the need of monitoring will be lesser as the radionuclide content is supposed to be well below the limits.

TABLE II
Values of Some Waste Acceptance Criteria

a) Mobile activity limits (Bq/vault):			
beta, gamma radionuclides	2.4 E + 12		
⁹⁰ Sr	2.3 E + 08		
b) Activity limits:			
	Package (Bq)	Vault (Bq)	Double row (Bq)
⁹⁰ Sr	7.8 E11	1.0 E14	1.1 E16
¹³⁷ Cs	2.2 E11	2.9 E13	3.2 E15
²³⁹ Pu	3.9 E06	5.1 E08	5.6 E10
²⁴¹ Am	2.3 E06	3.0 E08	3.4 E10
Note: ⁵⁴ Mn, ⁶⁰ Co, ¹⁰⁶ Ru, ¹⁴⁴ Ce are not limited			
c) Surface dose rate:			
200 L steel drum	0.9 Gy/hour		
d) Leachability during 2 day immersion test:			
Specific beta, gamma activity of waste (MBq/dm ³)	Permissible Leachability (%)		
> 200	0.4		
0.02 - 200	4		
< 0.02	unlimited		
e) Compressive strength of cementitious waste form:			
Activity up to 200 MBq/dm ³	5 MPa		
Note: Cylindric specimens 40 x 40 mm			

Technical Parameters

Waste form that shall be disposed of in a repository must meet several technical requirements, such as a weight limit

that respects manipulation appliances, shape dimensions allowing for the use of standard containers and hooks, waste package without any corrosion or mechanical damage, and definition of the loose and lump waste forms.

Formal Requirements

Some specifications are needed to maintain the desired role and behavior of the disposal system irrespective of the results of safety analyses. Among others strong limitations of disposal of toxic, pyrophoric and explosive materials is of primary importance. The control of the presence of free liquids belongs to this group as does the ensuring of integrity of each waste package for the operational period of the repository.

Administrative Needs

Full identification of each waste form is necessary in the course of manipulation, storage, transportation and operation of the repository. To cover this need a number/letter code is proposed bringing the unambiguous information about a producer, year of production, serial number, package type and content. Furthermore, a package is labeled by 0 - 3 color stripes according to its surface dose rate.

Waste tracking and recording is of the same importance. All passports and records about a positioning of waste package in the repository are doubled and kept at different places.

SUMMARY

The presented set of acceptance criteria for the disposal of radioactive waste in the shallow land repository at Dukovany is developed so that the safety of the disposal system can not be nonacceptably affected. The level of acceptability is expressed as an individual dose limit to the general public, the value of which - 10 μ Sv/y - is within "de minimis" principle.

The safety calculations interpreted two groups of scenarios: those describing normal and accidental conditions of operational and institutional periods and those representing the disposal system behavior during unrestricted use of the repository site. As a result the limits of mobile activity, specific activity of waste, and radionuclide inventory in vault and in the completed part of the repository were established.

The waste acceptance criteria were completed by technical, formal and administrative requirements assuring that all designed goals were met.