Nikolaiev Ie., Alekseeva Z., Kondratyev S., Rybalka N., De Hoyos A., Zambardi F.

Safe Management of Emergency-Related Radioactive Waste in the Chornobyl Exclusion Zone

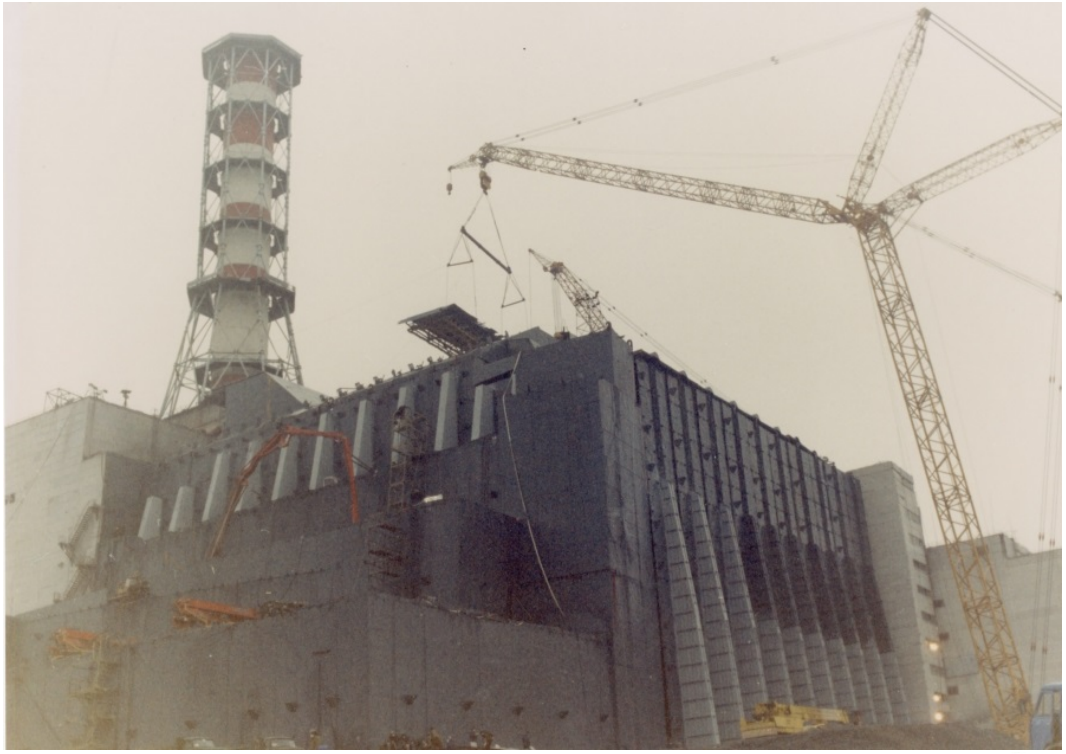
STATE SCIENTIFIC AND TECHNICAL CENTER FOR NUCLEAR AND RADIATION SAFETY SSTC NRS
RISKAUDIT IRSN/GRS International
iter consult
EUROSAFE 2016

Contents

- Introduction
- General approach
- Stages and scope of analysis of Radioactive Waste Temporary Localization Sites radiological impacts
- Conclusions

Introduction

- The world's most severe nuclear accident destroyed Unit 4 of the Chornobyl NPP in April 1986
- Confining building (Shelter) was erected in November 1986



Introduction

- New Safe Confinement construction (September 2016)
- Length - 162 m, width - 257 m, height - 109 m

Introduction

- During the acute phase of the accident at Chornobyl NPP (Unit 4), emergency radioactive waste (radwaste) was collected in the area around the NPP for its further localization.
- The major part of high- and intermediate-level radwaste is located in concrete modules, called radioactive waste disposal sites (RWDS).
- Intermediate- and low-level radwaste is confined in the trenches and clamps (points) called radioactive waste temporary localization sites (RWTLS)

Introduction

- There are 3 RWDS in the Exclusion Zone: “Pidlisnyy”, “ChNPP Stage III”, “Buriakivka”
- Safety improvement of “Pidlisnyy”

Before

After

Introduction

- There are 9 RWTLS around ChNPP: “Yaniv Station”, “Oil Storage”, “Sand Plateau”, “Red Forest”, “Old Construction Base”, “New Construction Base”, “Prypiat‘”, “Kopachi”, “Chystohalivka”.

- Main characteristics of RWTLS:
  - total area of about 12 km^2;
  - estimated number of trenches/clamps (points) is about 1000;
  - total volume of radwaste is estimated as 1 million m^3

Introduction: RWTLS Mapping

Introduction: RWTLS Examples

"Rudyy Lis" (Red Forest)

“Kopachi”

“Pischane Plato” (Sand Plateau)

Introduction

- In the framework of the European Union INSC project U3.01/10 (UK/TS/46), supporting the Ukrainian regulatory body (SNRIU) in regulation of safe radwaste management, a “Guideline for Safety Assessment of Temporary Localization Emergency Radioactive Waste Sites in Chornobyl Exclusion Zone” was developed by experts of RISKAUDIT IRSN/GRS International and the State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS).
- The Guideline defines methodological recommendations for implementation of iterative safety assessment of RWTLS and determines measures for their remediation.

General approach

- Strategy for RWTLS management should be based on their long-term safety assessment taking into account their location in the Exclusion Zone (EZ) where there is no population and gradual Zone size reduction is planned (reduced EZ).
- Consideration of RWTLS as a past practice (existing exposure situation) to make justified decisions.
- Based on safety assessment results, decisions should be made on terms, sequence of radwaste removal or inexpediency of radwaste removal, and on corrective measures to improve safety.
- RWTLS management strategy should include quality system provisions

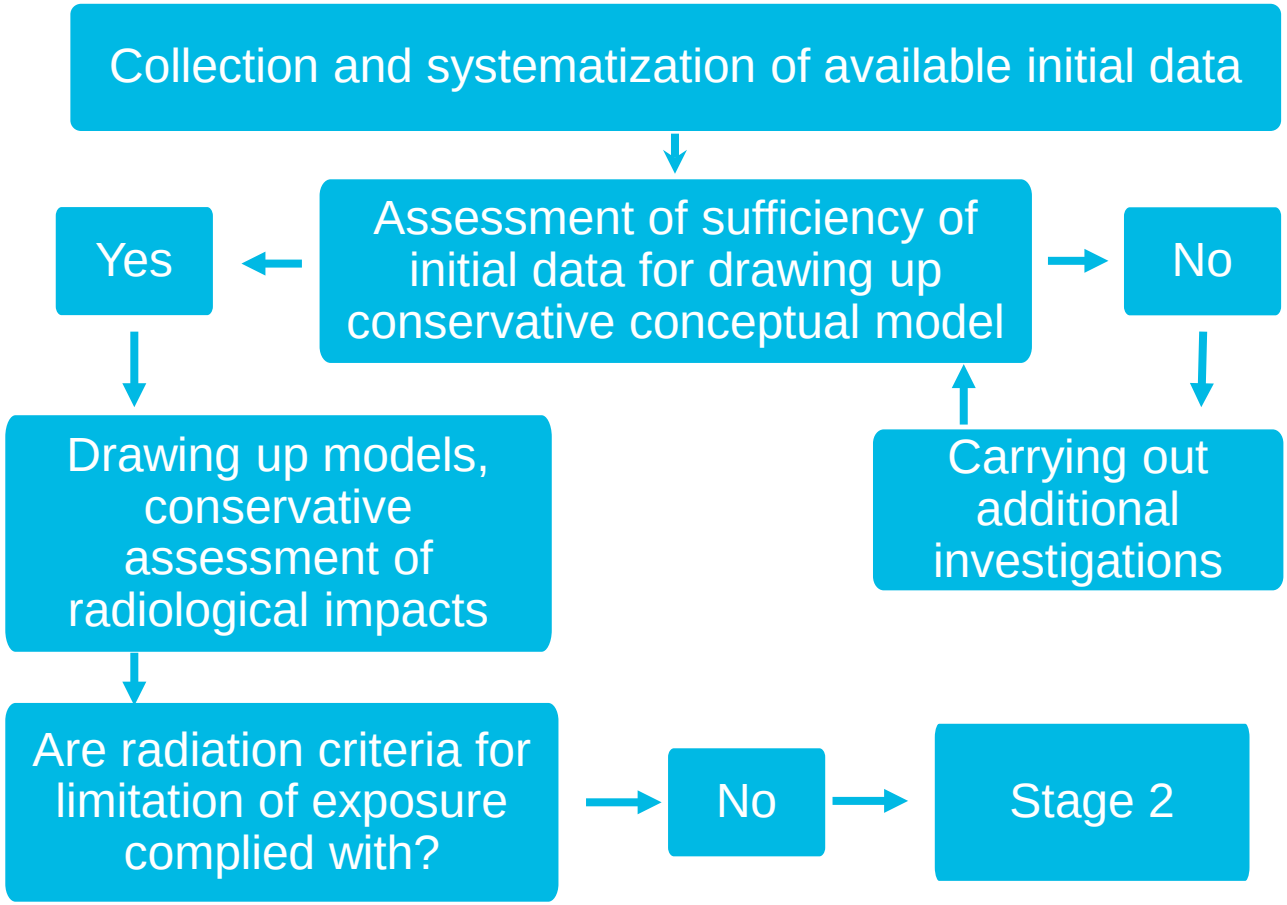
General approach: Assessment stages

Stage 1 – Conservative assessment of radiological impacts of RWTLS

Stage 2 – Upgraded assessment of radiological impacts of RWTLS

Stage 3 – Determination of remediation measures to ensure adequate safety level of RWTLS

Assessment stage 1



Assessment stage 1: Initial conservative data

- Exclusion Zone characteristics:
  - overall site description, current and forecast activities at the territory, demographical data, environmental conditions, natural and technogenic hazards, etc.
- RWTLS characteristics:
  - number and arrangement of trenches/clamps of each RWTLS; geometrical parameters, radwaste inventory and characteristics, presence of water in trenches and its contamination; characteristics and condition of caps over trenches/clamps; hydrogeological conditions; characteristics of contamination in the RWTLS location area, etc.

Assessment stage 1: Initial conservative data

- It is permitted to divide each RWTLS area into sections so that there are no significant differences in characteristics within the specific "uniform" sections
- In case of such division of RWTLS into sections, it is permitted to characterize them by generic values of parameters (with certain conservatism)
- In particular, it is permitted to use, for a particular "uniform" section, generic (conservative) accumulative values of radwaste amount, area of trenches/clamps with radwaste, etc.

Assessment stage 1: Conservative analysis

- Safety analysis of RWTLS is carried out by determination of evolution scenarios for conditions of radwaste localization, release and spreading of radioactivity from trenches/clamps and outside the borders of RWTLS and development of appropriate conceptual and mathematical models
- Scenarios are developed under the assumption that measures on maintenance of RWTLS safety are not implemented, and radwaste local conditions evolve in a natural way
- Scenarios for RWTLS sites must be determined based on screening of FEPs list (ISAM)

Assessment stage 1: Conservative analysis

- RWTLS safety assessment should be based on prediction calculations of impacts as a result of both gradual leaching of radionuclides and their migration to the location accessible for people and occurrence of events that impair the retention properties of the cap over trenches/clamps or enhance release and transport of radionuclides outside the places of their localization
- In determining routes of radionuclide transfer and locations of critical groups of population, gradual changes in EZ with time are taken into account as regards EZ reduction

Assessment stage 1: Conservative analysis

- The following potential routes for spreading of contamination are taken into account: with groundwater and surface water; through atmospheric air during transfer of gases, aerosols, dust, parts of vegetation from the surface of RWTLS; propagation of contamination to biomass
- The condition of cap over trenches/clamps will gradually degrade, in particular, due to wind erosion, rain and vegetation
- Spreading of contamination due to a fire on RWTLS sites is taken into account, considering contamination of vegetation and wind transport

Assessment stage 1: Conservative analysis

- In the period when only reduced EZ is the element of passive control, scenarios of temporary intrusion of people to RWTLS sites are considered. One of these may include presence of tourists on RWTLS site for a certain time with maximum use of natural resources (bonfires, use of water, collection of berries, etc.)
- For the remote period after termination of existence of the reduced EZ or after loss of memory of the site, permanent residence on site of RWTLS and possible types of human activities (civil and road construction, water use, etc.) are considered

Assessment stage 1: Compliance with radiological criteria

Period	Individual annual normal exposure dose	
	Population critical group	Adjacent facilities staff
Existence of reduced EZ	0.3 mSv – total annual dose from all RWTLS outside reduced EZ (para. 2.15, SSR-5)	2 mSv/year (Table 5.1 of NRBU-97 for category B staff)
After termination of reduced EZ existence or loss of memory of the site	0.3 mSv – total annual dose from all RWTLS outside reduced EZ (para. 2.15, SSR-5) 1 – 20 mSv/year – total annual dose at RWTLS territory from all RWTLS and other sources of exposure (para. 2.15, SSR-5)	

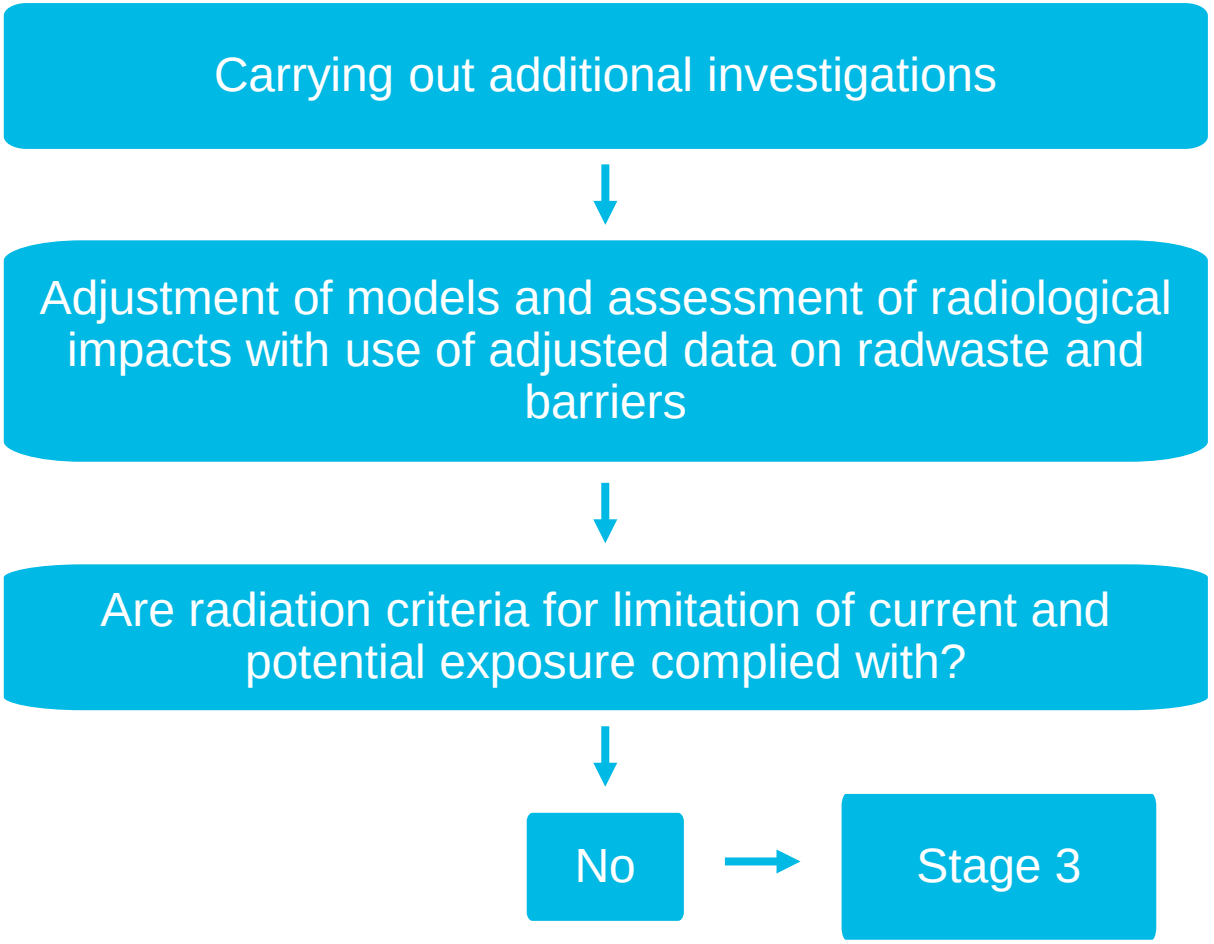
Assessment stage 1: Compliance with radiological criteria

Period	D – annual dose of potential exposure P – probability of critical event
	Critical group of population and staff of adjacent facilities
Before conditional release from regulatory control	$D \leq 50$ mSv, $P \leq 1 \times 10^{-2}$/year (Table 2.1 of NRBU-97/D-2000) $D > 50$ mSv, $P \leq 2 \times 10^{-5}$/year (Table 2.1 of NRBU-97/D-2000)
After conditional release from regulatory control	$D \leq 1$ – 50 mSv, $P \leq 1 \times 10^{-2}$/year (para. 4.3.7 of NRBU-97/D-2000)

Assessment stage 1: Ranking of RWTLS (sections)

- The sections that give the highest radiological impacts (or trenches/clamps for unintentional human intrusion scenarios) are selected
- Routes of radionuclide spreading that give the main contribution to radiological impacts are determined for the most hazardous sections
- The scenarios, "uniform" sections and routes of radionuclide spreading that lead to violation of radiation and health & safety regulatory values for normal and/or potential exposure of population and staff of nearby facilities are separately determined

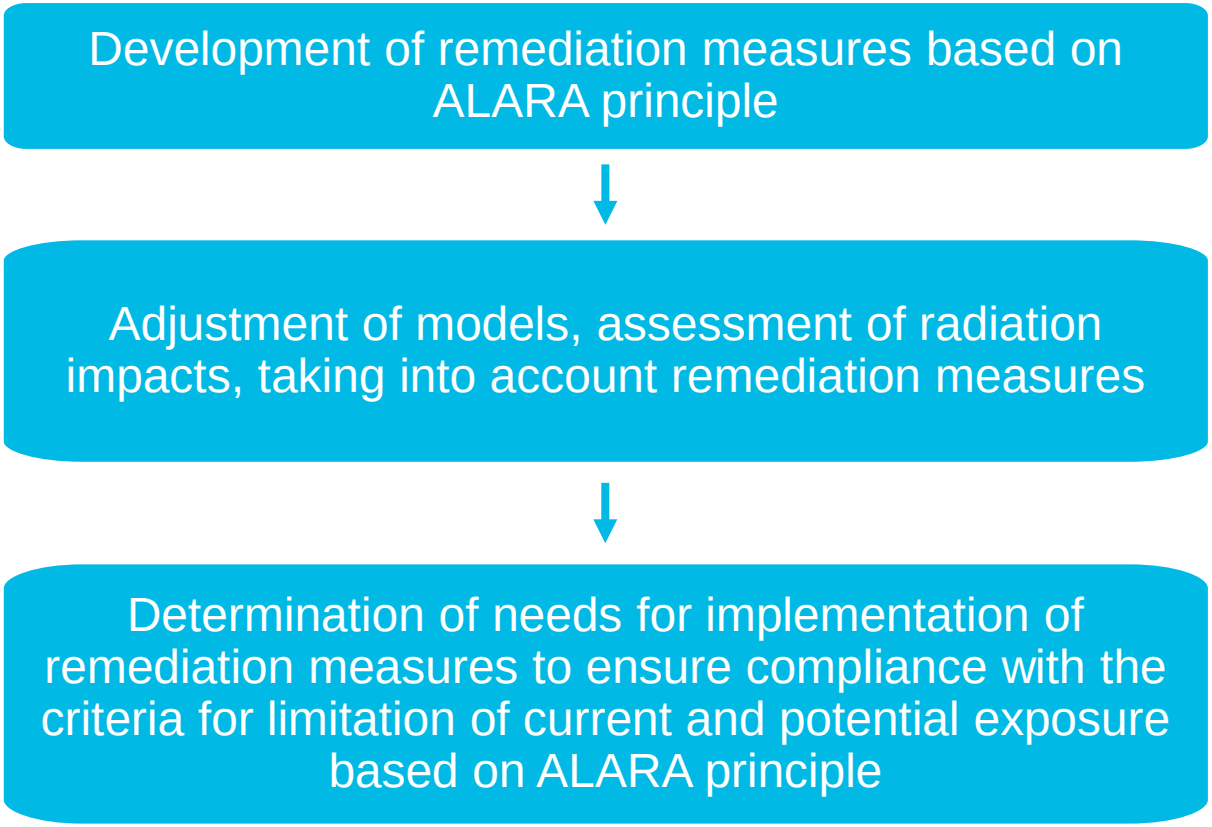
Assessment stage 2



Assessment stage 2:

- Needs are identified for additional data and carrying out of additional studies including also sampling and characterization of radwaste
- Based on upgraded models and/or scenarios, the calculations of radiological impacts of RWTLS are adjusted
- The results of adjusted calculations are compared with the criteria for admissible radiological impacts and sufficiency of RWTLS safety level is assessed, as at stage 1

Assessment stage 3



Assessment stage 3: Adjustment of assessments

- Adjusted assessments of radiological impacts are carried out taking into account of implementation of respective remediation measures
- Based on the results of assessments, it is determined to what extent each remediation measure reduces radiological impacts.
- To make a decision on implementation of a specific remediation measure, the ALARA optimization principle is applied
- In case of radwaste removal, the feasibility of new facilities for disposal of the removed radwaste should also be assessed

Conclusions

- The approaches to RTWLS safety assessment shall be considered to make justified decision on measures for RTWLS remediation considering EZ barrier function
- Iterative safety assessment is proposed for ranking of RWTLS by their potential hazard
- In the framework of the industrial INSC Project U4.01/10 “Support to Radioactive Waste Management in Ukraine” Task D “Investigation of Radioactive Waste Burial Sites and Interim Storages in the Chornobyl Exclusion Zone”, safety assessments and recommendations for these nine RWTLS are being developed

Thank you
for attention!