TECHNICAL DESCRIPTION OF RADRUE

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EXECUTIVE SUMMARY

The accident at the Chernobyl Nuclear Power Plant (ChNPP) on April 26, 1986 was followed by a phase of clean-up and recovery, which lasted till 1990. About 200,000 workers (so called liquidators) took part in cleaning activities around the Chernobyl Nuclear Power Plant (ChNPP) in 1986-1987 (the years of largest radiation hazard and highest intensity of clean-up operations). The Chernobyl liquidators were exposed to various levels of ionizing radiation. Individual exposures were monitored inadequately or were not monitored at all for the majority of liquidators. There were also problems with registration and archiving of the results of dosimetric monitoring. As a result, individual dose estimates for liquidators are insufficient in scope and quality. But demand for reliable dosimetric information is high. This information is required for assessment of the radiation doses obtained by clean-up workers to estimate level of damage and possible compensation. Besides there are several on-going epidemiological studies on Chernobyl clean-up workers that critically depend on the availability of unbiased and accurate individual dose estimates for all study subjects. The main requirements for the dosimetry of the epidemiological studies are: (i) doses for all cohort members must be estimated by the same method, (ii) precision of all doses must be not very sensitive to the dose level, and (iii) the dose estimation method should be applicable to all subjects, including those that are deceased. The last requirement is particularly significant for the leukemia study, as this disease has a large probability of lethality and many of the cases had already died at the time the studies began.

None of the previously available methods of retrospective dosimetry can meet all these criteria:

- Official Dose Records (ODR) – the dose values recorded in the State Chernobyl Registry1 - are available for only about 50% of registered liquidators and, as a rule, are biased upwards.
- Biodosimetry techniques like EPR (Electron Paramagnetic Resonance) analysis of tooth enamel or FISH (Fluorescence In Situ Hybridization) analysis of blood lymphocytes are limited by labor intensive analysis, insufficient availability of samples (EPR), or inadequate sensitivity threshold (FISH). Besides, both techniques are applicable only to live subjects.
- The Analytical Dose Reconstruction (ADR) method, which was developed soon after the accident by the Institute of Biophysics in Moscow for the retrospective assessment of doses received by the ChNPP personnel during the first days after the accident, is applicable only to the skilled personnel of the ChNPP, who were able to describe comprehensively their actions and movements. Besides, ADR has the tendency to overestimate the actual exposures because it uses a conservative ‘radiation protection’ approach with regard to the assessment of dose rates and exposure times.

The method described in this report, named RADRUE – Realistic Analytical Dose Reconstruction with Uncertainty Estimation, is based on the ADR method, which was improved in the following ways: (i) use of ‘realistic’ rather than conservative parameter’s values, (ii) simplification of the interview process by elaboration of a questionnaire, and (iii) estimation of the uncertainties attached to the dose estimates by means of stochastic modeling.

An elaborate computer calculation technique was implemented. It includes user-friendly interface with look-up tables and maps, dose rate maps and databases, formal rules and operations manuals to guide experts processing questionnaire data and coding the information for computer entry. The description of the formalism of RADRUE methodology and discussion of particular solutions and features of computer-aided dose calculations are presented in this report, which includes:

- in Chapter 1, a description of the different groups of liquidators: their responsibilities, numbers, periods of activity, organization of work, and level of the radiation protection service;
- in Chapter 2, a general description of the RADRUE method: main idea and assumptions, components and structure;
- in Chapter 3, a presentation of the radiological data used in RADRUE: databases of the radioactive situation measurements, made in 1986 – 1990, when, where, and who made those measurements;
- in Chapter 4, a description of different geographical regions where liquidators operated and radiological situation in those regions;
- in Chapter 5, a description of the methods used to establish the radiological database, including interpolation and extrapolation in time and space of the available data for different geographical regions;
- in Chapter 6, the estimation of the uncertainties associated with all parameters of the models (exposure rates, shielding factor, repetition factor, etc);
- in Chapter 7, an evaluation of the reliability of the estimated exposure rates, which is demonstrated using examples;
- in Chapter 8, dose transfer factors for different groups of liquidators;
- in Chapter 9, a presentation and discussion of the dose limitation procedure, illustrated with examples;
- in Appendix 1, a list of files with the results of exposure-rate measurements used for construction of exposure-rate grids.

Although the RADRUE method has only been used so far in the framework of the Chernobyl accident, its characteristics make it suitable for application in a wide range of situations, such as radiation dose estimation for emergency responders and victims of any type of accident involving radioactive materials, including acts of radiological terrorism. The RADRUE method also can be used for emergency responders’ work organization: optimization of radioactivity measurements process; optimal evacuation route development; clean-up work planning, etc.

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