

DEVELOPMENT OF AN IMPROVED DOSIMETRY SYSTEM FOR THE WORKERS
AT THE MAYAK PRODUCTION ASSOCIATION

PROJECT 2.4

PROGRESS REPORT FOR FY-98

Submitted to the Office of International Health Programs, U.S. Department of Energy for
the US-Russia Joint Coordinating Committee on Radiation Effects Research

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PROGRESS REPORT, FY-98

I. Summary of Work

The Russian side of Project 2.4 has been progressing for the last several years. The prior U.S. team with the Russian team had developed an extensive list of specific tasks. For administrative purposes, some of the Russian investigators have been working from condensed, but inclusive, versions of the original task list. All tasks were reviewed with the Russian team in the April, 1998 meeting in Washington, DC and more extensively during the visit to Ozersk in September, 1998. These are updated below. In addition, more specific tasks were identified, and these are now presented.

During the 1998 fiscal year, a new management approach was implemented with the U.S. Team. In addition to this approach, there were budgetary changes that occurred. These new approaches and scientific issues associated with the Russian-U.S. collaborations under Project 2.4 are also summarized in this report.

Overall, we are pleased to report significant progress during FY-98. Moving forward in both internal and external dosimetry, with the internal and external teams agreeing on comparing with ICRP models and basic fluence and spectrum reconstruction, respectively. Preliminary quality assurance was completed by tracking the external and internal doses recorded in separate databases through to the primary documentation archived at FIB-1 and MAYAK.

II. Milestones and Deliverables Accomplished During the Reporting Period

A. Management Approach

This is a multi-disciplinary, multi-task, and operationally and scientifically complex project. The overall management of this project must remain flexible to accommodate the changing needs and requirements to fulfill the project goals. The management approach from the new US team may be summarized as:

- Budgetary constraints. The project must function within an austere budget. Clearly, there must be careful allocation of resources that fit the priority needs.
- Flexibility. We anticipate that the scientific and technical needs of this project will change as the program progresses. To ensure the necessary flexibility and optimal allocation of resources, all investigators understand that there will be no "entitlements" or "tenure" into the projects. Investigators will be included only to perform specific scientific or operational objectives.
- Open communication. Project 2.4 is central to all projects in Direction 2. For this reason, open and frequent communication among all projects, including the Russian collaborators, must be accomplished and maintained.
- Consultants and advisors. We will use consultants and advisors extensively in this project. A more formal Internal Advisory Group will be utilized to review all of the research plans and programs.
- Student involvement: The U.S. Team functions within a University environment and students will be used extensively in this work. This includes some undergraduate students, but primarily Masters-level or Doctoral-candidate students.
- Faculty appointments for Russian investigators: It is our desire to create a true academic collaboration with our Russian colleagues and investigators. Presently, 3

Russian scientists are being proposed for Adjunct faculty positions at the University of Utah. It is our expectation that these new faculty members will take an active role in the training of our students and participate in mutually agreed collaborative research.

- Departmental resources: To supplement the funding from the USDOE., some institutional support is being contributed to the conduct of this project. Mostly this would be to support the student research efforts in this project and include direct institutional support and some scholarship funds.

B. General Leadership Roles for the U.S. and Russian Teams

A joint meeting with the new Project 2.4 team leaders and the Russian team was held in Washington, DC in April of 1998. It was decided to identify the primary overall tasks and to assign primary and secondary leadership roles in these tasks. We emphasize that all tasks are to be conducted jointed, but this identified which group would take the leadership or primary role in implementing these tasks. These are summarized in the following table (all of the specific tasks to follow fall into these general categories).

Tasks	Primary Role	Secondary Role
External dosimetry:		
Gamma, beta, neutron doses	Russia	U.S.
Organ dose calculations	U.S.	Russia
Occupations histories	Russian	U.S.
QA/QC	Both	
Internal dosimetry:		
Internal model (FIB-1)	Russia	U.S.
New biokinetic model	Both	
Dose uncertainties	Russia	U.S.
Occupational histories	Russia	U.S.
Common identifier	Russia	U.S.
QA/QC	U.S.	Russia

C. Data Access Agreement

It is necessary to determine access needs and to obtain authorizations and agreements for subsequent use for all original raw data, original compiled data, and second generation data. It is also necessary to ensure that procedures are in place to protect the intellectual property rights of Russian investigators. (Khokhryakov, Romanov, Glagolenko, Vasilenko)

The Project 2.4 data access agreement (DAA) is, in essence, a tri-lateral agreement between the U.S., FIB-1 and Mayak, PA. The draft version of the DAA was reviewed by all parties during the September, 1998 visit. A revised DAA is being prepared in both English and Russian and is expected to be completed by November, 1998.

D. QA/QC

To implement the required comprehensive QA/QC for each task as required, (external and internal dosimetry) the 2.4 team did a preliminary study of 14 randomly selected cases associated with Project 2.3 to find monthly and annual doses, location and ease of access. Of the 14 cases, two cases were identified and their records were tracked from

the original journal entries at Mayak PA. through the Mayak computer database. These two cases were also found in the FIB-1 data base and followed through to the original notebook entries for their urine bioassays. The remaining twelve cases were followed from the Mayak data base to the original note book entries for urine bioassay. This preliminary investigation was successful in identifying several databases which had redundant information concerning external and internal dosimetry. Furthermore, confirming that the primary data still exists in two locations (FIB-1 and MAYAK). Using this information we are developing comprehensive guidelines to cross-check work location, bioassay, autopsy, external dosimetry, and internal dosimetry data recorded in the database and on primary documentation. It is expected that a comprehensive QA/QC process will be done in FY 1999 on the dosimetric and work histories data associated with cohorts of Projects 2.2, 2.3 and the new feasibility studies.

E. Internal Dosimetry

Progress on Original Tasks

Task 1. Compile all bioassay data (measurements of radionuclides in urine and feces) and make these data available for microfilming at FIB-1. (Menshikh)

Status: Completed during FY-98.

Task 2. Conduct initial meeting with Project 2.2 and 2.3 scientists to establish and maintain routine scheduled contact and to determine additional needs. (Khokhryakov, Menshikh, U.S. Team, Project 2.2 & 2.3)

Status: The initial meetings have been completed, however, this is an ongoing process. Coordination with investigators in Project 2.1 is necessary . The changes in leadership of Project 2.3 requires additional integration. Furthermore the integration of 2.4 with the new feasibility studies needs to be explored and defined.

Task 3. Design the structure and format for the final computerized data base to be established for the internal dosimetry part of Project 2.4. This will include a statement of what doses (and associated uncertainty) will be calculated for what organs over what time periods. (Khokhryakov, Menshikh, Romanov, Vostrotin, U.S. Team)

Status: The format of the database at FIB-1 has been established and there will be no changes until the first complete set of internal dose information is provided in April, 1999.

Task 4. Determine that the proposed structure and format of the internal and external dosimetry data bases at FIB-1 and Mayak PA will be compatible and consistent. Also consult with investigators from Projects 2.2 and 2.3 to ensure that their dosimetry data needs will be fulfilled insofar as possible by the proposed structure and format envisaged as a result of Task 4. (Khokhryakov, Menshikh, U.S. Team, Vasilenko, Fevraleev)

Status: This issue was explored during the QA/QC exercise during the September, 1998 visit. While the structure and format of the databases differs, individual records could be cross-checked at both locations. The initial dosimetry needs for Projects 2.2 and 2.3, in terms of monthly and annual doses, are being entered into the appropriate databases.

Task 5. Ensure that all bioassay data necessary for Projects 2.3 and 2.4 are entered into the primary computerized data base. (Menshikh)

Status: in progress.

Task 6. Develop algorithms for dose computations in accordance with the needs of Projects 2.2 and 2.3. For Project 2.3 this includes monthly doses for lung, liver, bone and bone marrow. (Menshikh, Khokhryakov, Romanov, Aladova, U.S. Team)

Status: It has been agreed that the initial internal dose calculations will be delivered in April, 1999, using the current FIB-1 biokinetic model and includes doses to various organs.

Task 7. Provide interim internal doses as needed for Projects 2.2 and 2.3 using the existing FIB-1 Pu metabolism and dosimetry model. (Menshikh, Khokhryakov, Romanov, Aladova, U.S. Team)

Status: As noted under #6, above, this will be provided by April, 1999.

Task 8. Conduct a comparative analysis of the most likely intake scenarios at work sites. (Suslova, Aladova, Vostrotin, with Mayak PA and U.S. Team)

Status: The occupational histories and information is also necessary to reconstruct gamma, neutron and beta doses. Thus this effort will be coordinated between the Mayak PA and FIB-1 and facilitated by the U.S. team. At FIB-1, some worker history information is being entered into the database and this information is obtained from the Central Personnel Department at Mayak, PA.

Task 9. Implement a Quality-Assurance (QA) and Quality-Control (QC) procedure for the entry of the bioassay data into the computerized database. (Suslova, Menshikh, Aladova, U.S. Team)

Status: An internal QA/QC procedure has been implemented that includes double entry in the data bases. See section D for general QA/ QC accomplishments.

Task 10. Modernize the existing biokinetic model of industrial Pu compounds and develop an improved dose-calculation method based on the changes in the modernized model. Make appropriate changes in the algorithms used for dose calculation. (Khokhryakov, Menshikh, Romanov, Vostrotin, U. S. Teams on Projects 2.4 and 2.1)

Status: To begin this modernization of the existing biokinetic model the 2.4 investigators agreed to do some initial comparisons with the existing FIB-model and the current ICRP model. Data specific to this modernization is being determined in conjunction with task 17. This will be implemented in FY-99 and will also involve investigators from Project 2.1.

Task 11. Perform analysis of errors and systematic biases and evaluate uncertainties of dosimetric parameters used for internal dose calculations; evaluate any possible correlations among the sources of uncertainty. (Khokhryakov, Suslova, Menshikh, Aladova, Alexandrova, U.S. Team)

Status: It was agreed that we would first distinguish possible system, measurement and other sources of errors. We would then use the uncertainties methodology established for the Hanford dose reconstruction models and developed by E. Gilbert (Project 2.2). Furthermore, we will also explore quantifying the uncertainties using perturbation methods. It was agreed in the Washington DC meeting, that this will also require close coordination with the specific needs of the investigators in Projects 2.2 and 2.3.

Task 12. Prepare manuscripts on internal dosimetry models (FIB-1 model) used for the initial internal dosimetry data. Additional manuscripts may include validation of the model (or corrections to the model) based on extrapolation of bioassay data with autopsy data. Khokhryakov, Suslova, Menshikh, Romanov, Chernikov, U.S. Teams for Project 2.4 and 2.1)

Status: The documentation and verification of the bioassay data and FIB-1 model and the secondary data derived from this model has been initiated. The first manuscript will be prepared in FY-99.

Task 13. Provide finalized monthly dose values and associated uncertainties to Project 2.3. In anticipation of this, provide a rigorous quality assurance assessment of the data base. (Menshikh, U.S. Team)

Status: Will not begin till FY99

Task 14. Provide final internal organ-dose values and associated uncertainties to Project 2.2. Values will be of annual doses up to the current time or for time of death. Methods of extrapolating doses into the future will also be provided. In anticipation of this, provide a rigorous quality-assurance assessment of the data base to be provided. (Menshikh, U.S. Team)

Status: Will not begin till FY99

Task 15. Research the feasibility of using existing whole body counter screening data for future dose-assessment purposes. (Chernikov, U.S. Teams on Projects 2.4 and 2.1)

Status: It was agreed that this is a very worthwhile task, but will be initiated after the installation of the new whole body counter (WBC) donated by 1.1. Construction has begun for the installation of the new WBC at FIB -1. Preliminary evaluations have been done using two existing WBC for reproducibility and accuracy. A better phantom is also being sought after. This effort will also be coordinated with investigators from 2.1 and 1.1.

Task 16. Conduct studies on dispersion and transportability of aerosols in workplaces that have not yet been investigated adequately. (Khokhryakov, Aladova, U.S. Team)

Status: Studies have been conducted on transportability (see publication listing). The characteristics of dispersion in the specific work locations have not been defined. Historical evaluations of the dispersion of industrial Pu compounds are being sought in the US archives. This research will be evaluated for applicability before further testing is implemented. To be initiated in FY-99 and coordinated with investigators from project 2.1

Task 17. Prepare and publish one or more final articles on the results of the dosimetric studies. Work with epidemiologists from Projects 2.2 and 2.3 to prepare joint papers on the results of the dosimetry/epidemiology studies. (Khokhryakov, Menshikh, Suslova, Vostrotin, Chernikov, U.S. Team)

Status: To be initiated in FY-99 after the first set of dose calculations are delivered.

F. External dosimetry

The effort to reconstruct external personal doses are organized under 5 major technical areas. Included under the technical areas are the original tasks accepted by the Scientific Review Group (SRG).

1.0 Reconstruction of Personal Doses from Gamma-Betas Radiation Fields:

1.1 Evaluate the gamma-energy spectrum for each relevant source of personnel exposure. A separate spectrum should be provided for each significant time period. (Vasilenko, Drozhko, Knyazev, Smetanin, US Team)

Status: The evaluation of the gamma-energy spectra at various plant locations is essential for correcting the external dose measurements and for calculations of organ dose levels. The source reconstruction is ongoing and supported by documents that detail the reactor operations (power logs and campaigns), alterations to plants infrastructure, fuel composition in billets, process of extraction and milling, etc. In addition, limited data exists from area radiation monitors.

1.2 Evaluate the degraded (source modified by shielding, scattering, etc.) gamma-energy spectrum for each relevant work location for personnel exposure. A separate spectrum should be provided for each significant time period. (Vasilenko, Drozhko, Smetanin, US Team)

Status: Generating gamma energy spectra for a number of work locations at reactor, Pu extraction (radiochemistry), and Pu milling plants are currently under way. It is expected that only a small number of spectra will be needed to effectively represent the gamma-beta radiation fields (Specifically 3 spectra for reactor, 7 spectra for radiochemistry and 4 spectra for Pu milling).

1.3 Develop methodologies for combining data on the energy response of different beta-gamma dosimeters with the degraded spectra to which individual workers were exposed in order to derive a corrected individual "film-badge" dose. (Vasilenko, Knyazev, Smetanin, Aleksandrova, US Team)

Status: This effort involves data being supplied by the GSF (Germany). A meeting is scheduled for November, 1998 to exchange information with the Germans on their specific tasks relative to this project.

Experiments were discussed that would investigate the influence of beta particles on the response of the original film badge using a linear accelerator at the University of Utah. A test matrix will be generated and reviewed before any tests are scheduled.

To assist in the evaluation of corrections (algorithms) generated by the GSF and MPA personnel, we have agreed to evaluate approximately 2 dozen dosimeters under known mixed neutron, gamma, and beta radiation fields.

- 1.4 Develop an algorithm for combining data on corrected individual "film-badge" dose with information on the workplace degraded energy spectra to derive work-location values of organ doses. (US Team)

Status: It was agreed upon that initial organ doses for gamma's (and neutrons) will be calculated from the methodology presented in ICRP pub. 51, "Data for Use in Protection Against External Radiation" adopted by the ICRP in 1987. The following are the initial organs to be evaluated: testes/ovaries, breast, red bone marrow, male lung / female lung, thyroid, eye lens, skin, and 5 fixed abdominal organs from ICRP 30. More advanced algorithms will be developed later.

Two gamma spectra, a hard and soft, were provided to see the significance of external exposure to the organs.

- 1.5 Develop an algorithm for calculating the uncertainty associated with the corrected values of individual "film-badge" and organ beta-gamma doses. (Alexandrova, US Team)

Status: Uncertainties can come from three areas : environmental/occupational, practices and circumstances, detection of key exposure parameters (film, TLD's. etc.) and methodology to calculate exposure and dose. Currently Dr. Alexandrova is starting with Ethel Gilbert's work, where algorithms were found to predict detection uncertainties from reconstructed doses of the Hanford radiation workers.

2.0 Reconstruction of Personal Dose from Neutron Radiation Fields:

- 2.1 Compile all neutron-flux data and make these data available for microfilming subject to the access needs and authorization. (Vasilenko, Smetanin)

Status: It is our understanding that this either has been completed or is in progress.

- 2.2 Compile all relevant data on workplace-neutron exposure, including the energy spectrum of neutrons to which exposure likely occurred. (Vasilenko, Drozhko, Knyazev, Smetanin, US Team)

Status: This work is in progress.

- 2.3 Evaluate the neutron-energy spectrum for each work location of interest as based on accumulated survey data. (Vasilenko, Knyazev, Smetanin, Alexandrova)

Status: This work is in progress.

- 2.4 Develop methodologies that will use both data from existing radiation monitors and simulations from neutron transport codes

Status: Two different codes will be used: MCNP and COG. This work is in progress.

- 2.5 Develop an algorithm for calculating the neutron dose for each individual according to each work location of interest. (Vasilenko, Knyazev, Smetanin, US Team)

Status: This work is in progress.

- 2.6 Develop an algorithm for calculating the uncertainty in individual-neutron dose. (Vasilenko, Knyazev, Smetanin, Aleksandrova, US Team)

Status: Uncertainties can come from three areas : Environmental/Occupational, practices and circumstances, detection of key exposure parameters and methodology to calculate exposure and dose. As with uncertainties with gamma doses, Dr. Aleksandrova is laying the theoretical ground work for estimating the uncertainties associated with neutron doses.

3.0 Input Doses in Database and Assure Data Quality:

- 3.1 Design the structure and format for all primary and secondary computerized data bases to be established for the external dosimetry part of Project 2.4. This will include a statement of what doses (and associated uncertainty) will be calculated for what organs over what time intervals. (Fevralev, US Team)

Status: The structure and format of the primary Mayak database has been established. A Web-server type database format (Sequel) has been implemented. An initial QA/QC on the database and the primary paper records was conducted in September, 1998 at Ozersk. The database contains the monthly and annual doses, as needed by Projects 2.2 and 2.3. The organ dose calculations will be done by the U.S. Team.

- 3.2 Compare the structure and format of the internal and external dosimetry data bases for consistency and compatibility. (Vasilenko, Fevralev, US Team, Menshikh)

Status: A "common identifier" between the FIB-1 and Mayak databases does not yet exist, although we found that individual records can be tracked between the databases by using a name and employment date.

- 3.3 Ensure that all external beta-gamma and neutron personnel dosimetry data are entered into a computerized data base. (Vasilenko, Knyazev)

Status: Much of the uncorrected beta-gamma doses have been entered into the various data bases that currently exist (Mayak and FIB-1). The common identifier problem in Task 3.2 needs to be resolved, along with using the algorithms developed in Tasks 1 and 2 to correct the doses. This work is in progress.

- 3.4 Provide a rigorous quality-control evaluation of the external beta-gamma and neutron personnel dosimetry database by performing a repeat entry of all data into the database. (Vasilenko, Knyazev, U.S. Team)

Status: A double-entry system for selected cases has been implement to account for data entry errors. A more rigorous QA/QC procedure was implemented that cross-checked the paper records as well as the entries in the multiple databases at both FIB-1 and Mayak PA during the September, 1998 visit to Ozersk.

- 3.5 Provide a rigorous quality-assurance and quality-control analysis of all secondary data bases generated. (Knyazev, Fevralev, US Team)

Status: A double-entry system for selected cases will be implemented to account for data entry errors, along with a cross-check of all calculations made for dose corrections. This work is in progress.

4.0 Interact with Personnel Associated with Projects 2.2 and 2.3:

- 4.1 Conduct initial meeting with Projects 2.2 and 2.3 scientists to establish and maintain routine scheduled contact and to determine additional needs. (Vasilenko, Knyazev, US Team)

Status: This has been implemented and will be an on-going process. In addition, we have incorporated the investigators from Project 2.1 into some of the tasks.

- 4.2 Process all data according to the algorithms developed for Tasks 1 and 2 in order to generate all secondary data bases, which will serve as input to Projects 2.2 and 2.3 (Knyazev, Aleksandrova, Fevralev, US Team)

Status: This work is in progress.

- 4.3 Deliver interim values of doses and associated uncertainties to Project 2.2 and 2.3 for their selected cohorts. (Vasilenko, Knyazev, Smetanin, Aleksandrova, Fevralev, US Team)

Status: This work is in progress.

- 4.4 Deliver final values of doses and associated uncertainties for the Project 2.2 and 2.3 cohorts. (Vasilenko, Knyazev, Smetanin, Aleksandrova, Fevralev, US Team)

Status: This work is in progress.

5.0 Generate Publications (Journals and Reports):

- 5.1 Prepare a manuscript describing the history of neutron-personnel dosimetry in use at the MPA from initial operation through the present time. This report will include data on the energy response of the detectors used, etc. (Glagolenko, Vasilenko, Drozhko, Knyazev, Smetanin, US Team)

Status: Several "Information Reports" on neutron dosimetry have been prepared the Russian Team. These include "The analysis of methods and organization of individual dosimetric supervision of neutron exposure" and "Development of technique for retrospective estimation of individual neutron doses". These provide excellent background material and information for the further reconstruction of neutron doses and the preparation of associated manuscripts.

- 5.2 Prepare one or more peer-reviewed papers describing the final external dose results calculated as a result of the external dose part of Project 2.4. (Glagolenko, Vasilenko, Drozhko, Knyazev, Smetanin, Aleksandrova, Fevralev, US Team)

Status: This work is in progress.

- 5.3 Work with epidemiologists from Projects 2.2 and 2.3 to prepare joint papers on the results of the dosimetry/epidemiology studies. (Glagolenko, Vasilenko, Knyazev, Smetanin, Aleksandrova, Fevraley, US Team)

Status: This work is in progress.

G. Deliverables for Internal and External Dosimetry UPDATE

Reports:

1. Prepare a report describing the history of gamma and neutron dosimetry in use at Mayak from initial operation through the present time (FY 1999)
2. Report on feasibility of using previously collected whole body count data (pending)
3. Prepare a report describing the assessment of energy spectra for all significant sources of personnel exposure (FY 1999)
4. Report on results of uncertainty analysis (FY 1999.)
5. Prepare a report that describes the algorithm for the calculation of doses to 22 (or more) specific organs (FY 1999)

Corrected Doses and Uncertainties:

6. Provide interim values of doses and associated uncertainties for project 2.2 and 2.3 cohorts (April 1999.)
7. Deliver final values of dose and associated uncertainties for Projects 2.2 and 2.3 cohorts (FY 2000.)

Publications (Journals):

8. Prepare one or more peer-reviewed papers describing the final external dose results for Projects 2.2 and 2.3 (FY 2000)
9. Peer-reviewed publications on the results of the internal doses calculated for Projects 2.2 and 2.3 (FY 2000)
10. Peer-reviewed publication of an updated plutonium metabolism and dosimetry model (FY 2000)
11. Peer-reviewed publication of comparison of results of the updated model to actual results from the analysis of autopsy samples (FY 2000)

III. Other Relevant Information, Including Relevant Trip Reports, Obstacles to Completion or Work Outline in FY Work Proposal, Unexpected Costs, etc.

Two meetings were attended by the team members of 2.4; Washington DC USA and Ozersk Russia.

1. Washington DC - This meeting was attended by Russian and US PIs of 2.4, representatives from Moscow, US DOE, and projects 2.2 and 2.3. This meeting was successful in updating the new US PIs on their Russian counterparts current progress. 2.4 tasks were discussed and refined. Leadership responsibilities were assigned and approximate completion dates were agreed upon. The current plan has been incorporated into this document.

2. Ozersk, Russia. This meeting was attended by the task 2.4 team members. Briefly, the PIs and associates exchanged information and proposed new methodologies to complete the required tasks. A rough draft of the data access agreement was exchanged. The US team members toured several Mayak PA and FIB-1 sites, including fuel reprocessing, spent fuel storage, Lake Karachay, dosimetry and bioassay labs. These tours provided a unique insight into the current and historical working conditions of the cohort. Additionally this site visit was used to do preliminary QA/QC of dosimetric data.

IV. Publications and Preprints

"Classification of alpha - active workplace aerosols based on the coefficient of transportability as measured by the dialysis method" Journal of Radioanalytical and Nuclear Chemistry Vol. 234 Nos 1-2 (1998)