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2010 Annual Health Physics Report for the HEU Transparency Program

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Introduction

During the 2010 calendar year, Lawrence Livermore National Laboratory (LLNL) provided health physics support for the Highly Enriched Uranium (HEU) Transparency Program for external and internal radiation protection. LLNL also provided technical expertise related to BDMS radioactive sources and Russian radiation safety regulatory compliance. For the calendar year 2010, there were 141 person-trips that required dose monitoring of the U.S. monitors. Of the 141 person-trips, 129 person-trips were Special Monitoring Visits (SMVs) and 12 person-trips were Transparency Monitoring Office (TMO) trips. In 8 of these TMO trips the TMO monitors participated also in the UEIE SMVs and in 2 TMO trips the TMO monitors participated in UEIE and MPA SMVs. There were three monitoring visits (source changes) that were back-to-back SMVs with a total of 25 monitors. LLNL's Hazard Control Department laboratories provided the dosimetry services for the HEU Transparency monitors.

External dosimetry

LLNL provided 568 TLD dosimeters in 2010 for monitoring potential external dose: 256 personal dosimeters, 216 control dosimeters and 96 spares to Pragma in Yekaterinburg and TMC in Moscow. Approximately half of the dosimeters supplied were returned and were not read. This includes the unused spare dosimeters from Yekaterinburg and Moscow and both the personal and control arbitration TLDs left in Russia until a post trip dose letter is provided. However, both read and unread TLDs needed to be zeroed and re-calibrated before subsequent use.

Spare dosimeters
In 2010, all HEU Transparency monitors went on assignments in Russia with a complete set of personal and control dosimeters. In order to avoid a failure of a trip mission due to lost dosimeters at customs, a pool of 24 spare dosimeters was maintained at TMC in Moscow, in addition to the 24 spare TLDs at the Pragma office. In 2010 sixteen (16) spare dosimeters were used when UEIE SMV 10-2 team dosimeters were not delivered to Russia after flight cancellations due to volcano eruptions in Iceland. The current number of spare dosimeters allows replacing the loss of all dosimeters of one single team. In such cases the spare dosimeters will be replenished by the next team. In normal situations the spare dosimeters are exchanged semi-annually.

Dose information from the Russian dosimeters
The dose readings from the Russian TLDs (dosimeters) compare well within the statistical uncertainties with the readings from the U.S. dosimeters. The information from the Russian TLDs together with the arbitration TLDs (monitor's second U.S. dosimeter) is instrumental in resolving discrepancies and anomalies in the readings of the primary U.S. dosimeter. In 2010 we received the external dose readings from the Russian TLDs supplied to the U.S. monitors by the plants as follows:

- SChE – for all SMVs and all monitors
- MPA – for all SMVs and all monitors
- ECP – for all SMVs and all monitors
- UEIE - none

External dose investigations
There have been 6 external dose investigations in 2010 which resulted in assigning an insignificant dose to two monitors. Both external doses were very close to the recording level of 10 mrem. They resulted from trips to SChE most likely when the same monitors inventoried multiple times large quantities of HEU cylinders. The other investigations resulted in zero dose assignments. For any dosimeter reading above 10 mrem, the arbitration TLD was analyzed together with the reported dose from the Russian TLD, when available, in order to evaluate if the monitor has/has not received an occupational dose from the HEU assignment in Russia. The arbitration and Russian TLDs, the radiological data we receive from the plants and personal interviews are used to resolve radiation exposure investigations.

No other external dose concerns were raised during the 2010 calendar year.

Logistics and dose reporting
Customs letters for both the U.S. and Russian customs were included in the dosimeters packages for each trip to facilitate customs inspections. LLNL retrieved all 2010 arbitration dosimeters from the monitored Russian nuclear facilities. In 2010 LLNL provided DOE's HEU Transparency Program management with post trip dose reports after each trip. All HEU monitors, but two, received zero or below the recording level doses from external radiation exposure in 2010. The two positive external doses (22 and 15 mrem) were close to DOE recording limit of 10 mrem and are well below the U.S. and DOE regulatory limit for occupational exposure (5,000 mrem).

Internal dosimetry

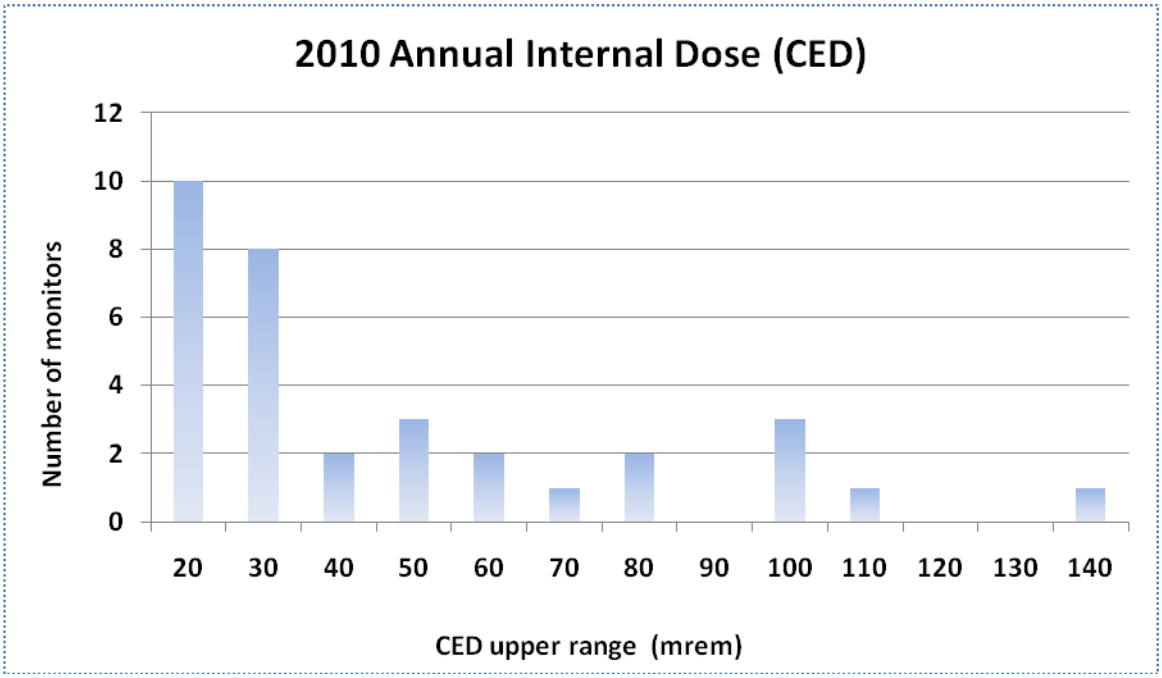
All HEU Transparency Program monitors who had participated in assignments in Russian uranium processing facilities in 2010 had provided one-time only baseline bioassay samples prior to the start of their involvement with the HEU Transparency Program and samples immediately after each trip. A total of 149 bioassay samples were submitted in 2010: 129 post-trip for uranium 235 and 238 and 20 follow-ups. All post trip bioassay samples from the 2010 calendar year were analyzed and the respective internal doses evaluated.

Bioassay sampling
In the past year LLNL introduced a new bioassay technique that resulted in 30 to 50 times improvement in the measurement of the Uranium content (both U-238 and U-235) in the bioassay sample. All 2010 bioassay samples were screened and re-evaluated using the improved procedure. In addition to the measured uranium isotopes mass concentration in the samples, the ratio of U-235/U238 in the obtained samples was taken into account when evaluating the Committed Effective Dose (CED, i.e. internal dose).

Internal dose evaluation

The minimum detectable internal dose (MDD) from uranium bioassays depends on several factors, two of which are the chemical and physical form of the uranium compound and the time elapsed between a potential uranium intake and the time the bioassay sample was provided. The available information on the chemical and physical forms of the uranium compounds that may be encountered in the areas visited by the U.S. monitors, as well as the obtained plants' radiological data, were used in evaluation of the monitors' internal doses. Conservative assumptions were used where multiple areas were visited or specific information was not available. Each individual's dose assessment took into account the specific areas visited by the monitor in the plant. HEU Transparency Program monitors are providing bioassay samples shortly (typically within 1-2 days) after their return to the U.S.A. As a result we are now able to determine internal doses (CED) well below the recording level of 10 mrem.

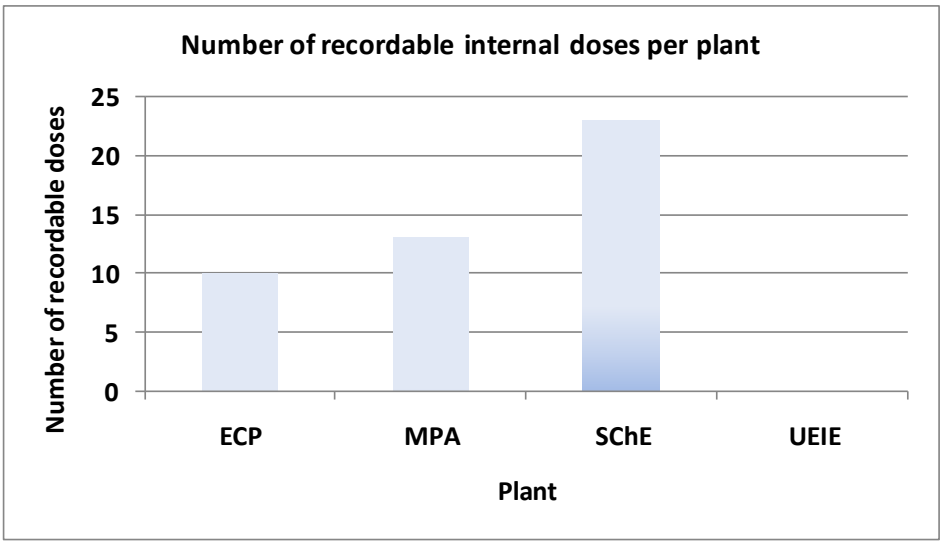
Below is a chart of the distribution of the internal doses for the 2010 year. Out of the 129 evaluated internal doses, 96 were "zero" or below 10 mrem (74.4%); 23 were between 10 and 50 mrem (17.8%), 8 were between 50 and 100 mrem (6.2%), and only 2 (1.6%) were between 100 and 140 mrem. There were no internal doses above 134 mrem for 2010. Bioassay results (uranium content in the bioassay sample) for internal doses below 10 mrem are to be kept compliant with the DOE rules, but the internal doses below 10 mrem are not to be recorded. In the annual internal dose chart below the horizontal axis "CED upper range" of 20 mrem includes the range from 10 to 20 mrem; the CED upper range of 30 mrem includes the range from 20 to 30 mrem and so on.



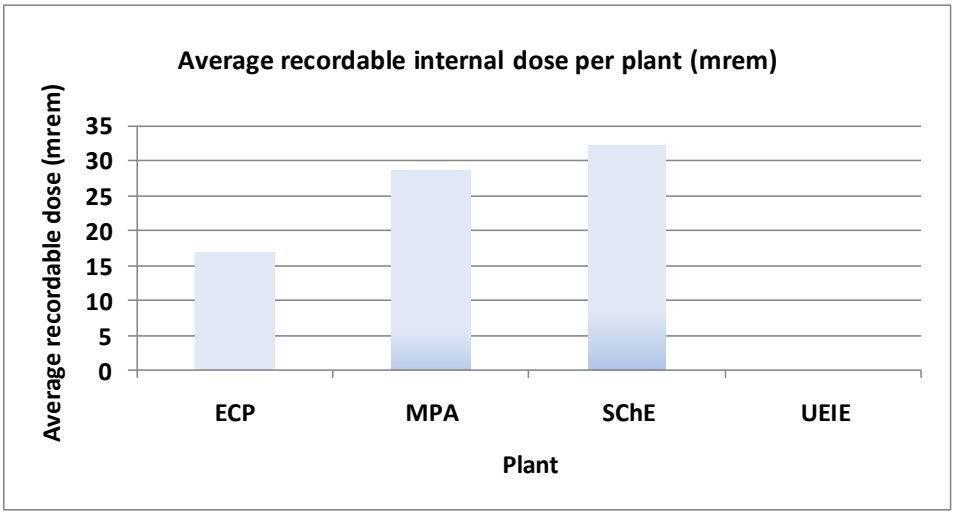
The DOE annual total dose limit for a radiation worker is 5,000 mrem. The evaluated internal doses are well below this value and represent a negligible risk to the monitors's

health. The evaluation of the respective dosimetry and bioassay results indicates that Federal or DOE Radiation Protection Standards have not been exceeded as a result of the HEU Transparency Program assignments in 2010. For perspective, the annual average dose to a person in the U.S.A. from natural background (excluding medical exposures) is approximately 150 mrem at sea level and at higher elevations is several times higher (e.g. at 7200 feet is approximately 450 mrem). The average annual dose to the U.S. population is 620 mrem including manufactured radiation sources (e.g. medical exposures).

The internal dose data indicate that the monitoring areas in the plants are different from a radiation safety point of view. The chart below shows how many recordable (>10 mrem) internal doses per plant were received by the HEU monitors in 2010. There were no recorded internal doses for UEIE.



The average recordable internal dose for 2010 was the highest for SChE and MPA and was zero for UEIE (see the chart below).



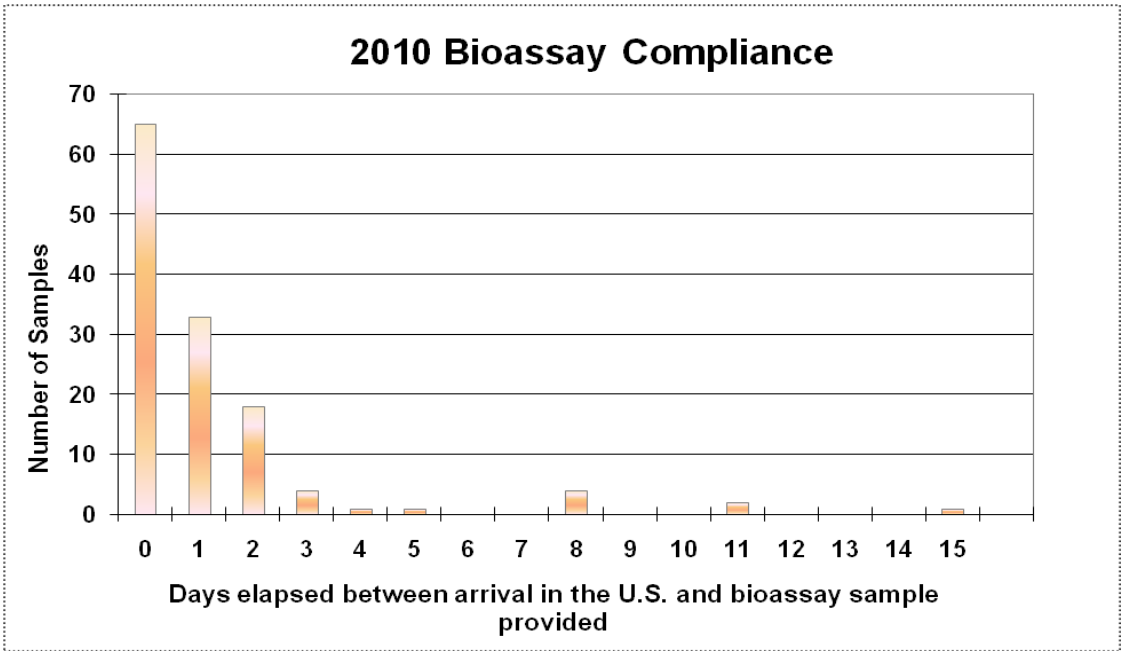
The percentage of the monitors with recordable internal doses from the total monitors visited the plant is 38.5% for ECP, 54.2% for MPA and 56.1% for SChE. No internal doses were recorded for monitors visiting UEIE in 2010.

The internal dose is assigned based on the bioassay result (content of uranium compounds in urine), appropriate biokinetic models, chemical and physical form of uranium compounds, and other pertinent information. The minimum detectable internal dose (MDD) from uranium bioassays depends on several factors, two of which are the chemical and physical form of the uranium compound and the time elapsed between a potential uranium intake and the time the bioassay sample was provided. We cannot control the first parameter, however we can try to shorten the time the bioassay sample is collected by obtaining it as close as possible to the day of the return to the USA. This will improve the accuracy of the internal dose assessment and will lower the detection limit.

Bioassay sample compliance

The established bioassay procedure requires each monitor to provide a post trip bioassay sample within 3 days of arrival in the USA. For 2010 calendar year, 93% of the samples were in compliance with this requirement, with the average time interval between the arrival of the monitors in the USA and the providing of the post trip bioassay sample being 1.23 days. Only 3 monitors have provided bioassay sample more than 10 days after their return to the U.S.A

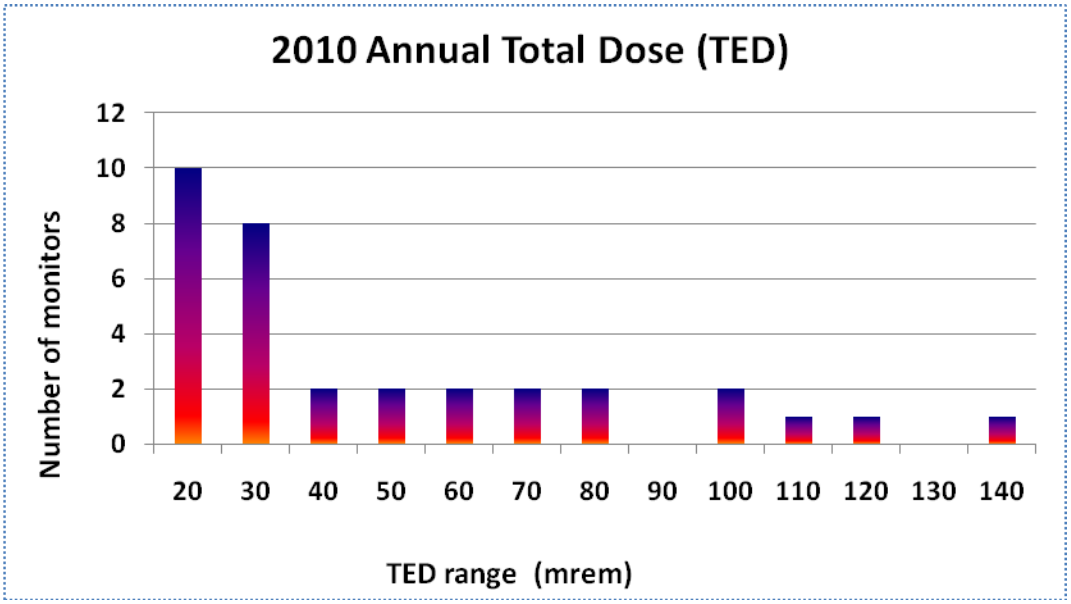
The chart below provides information on the bioassay sample compliance for 2010 calendar year.



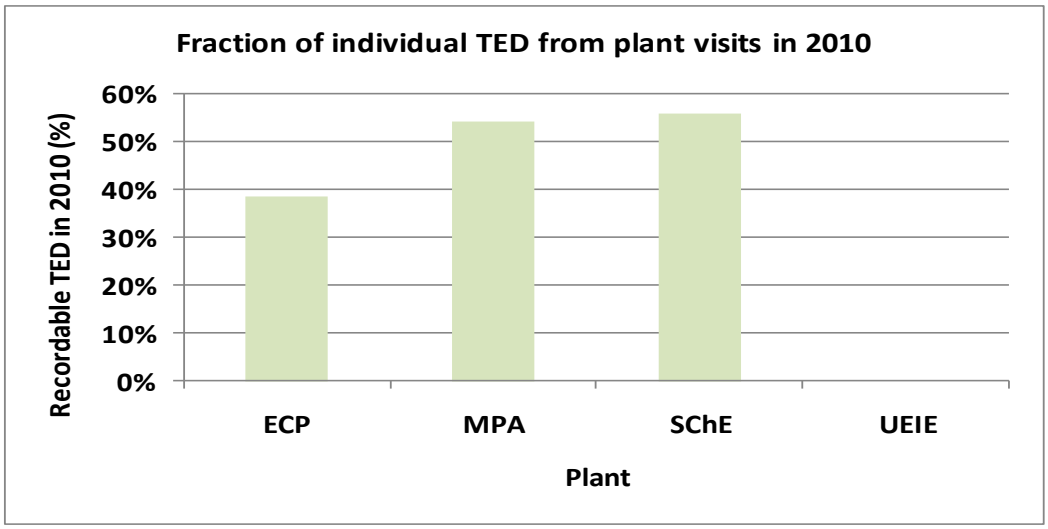
In 2010, LLNL provided the HEU Transparency Program management with quarterly internal dose reports (bioassay reports) containing information on the internal dose, the baseline bioassays, the procedure compliance and the status of bioassay samples received, analyzed and in process of being analyzed.

Total annual dose for 2010

The total annual dose (Total Effective Dose = TED) for 2010 is composed of the external and internal doses received from all trips in the calendar year. Since only two monitors received external doses in 2010 the annual individual TED distribution below is very similar to the internal dose distribution.



The chart below provides the percentage of the positive annual TED (≥10 mrem) from all visits in 2010 to a particular plant. Half of the SChE and MPA monitors received recordable doses, while no monitor at UEIE received any dose in 2010.



HEU health physics information database

LLNL maintains a confidential database to support the reporting of HEU radiation protection data. Official dosimetry data are stored in the LLNL's Radiation Protection Functional Area database. The HEU database contains historical external and internal dose information for every HEU Transparency monitor, as well as specific information for each trip, TLDs supplied, returned or left in Russia, baseline bioassays, submitted signed exposure release forms and monitor's data. The health physics database is essential for generating the post trip and the annual dose reports, as well as for any future inquiries. In order to comply with the provisions of the Privacy Act of 1984, we have obtained and keep on file signed Radiation Exposure Release forms for all HEU Transparency monitors that had assignments in the calendar year 2010.

The individual annual occupational dose report for each monitor for 2010, detailing the total dose as well as the external and internal doses from all HEU monitoring assignments, was mailed to each monitor in April 2011.

2010 Radiological data from the Russian plants

The 2010 radiological data, received from the Russian uranium processing plants under the HEU agreement, indicate that there are no radiological concerns for the U.S. monitors working in Russia who follow the work and personnel protection guidelines. The plant radiological data include gamma exposure rates, airborne and removable surface contamination levels in the areas visited by the U.S. monitors. These data supplement the information from the U.S. dosimeters and the bioassay sample analysis. The HEU Transparency Agreement Annexes have provisions that the radiological environment data for the areas of the Russian plants visited by the U.S. monitors be provided to the U.S. However, they do not specify what data, in what format, for what time intervals, or any other details. For example, a provision for sharing contamination or radiological accident data affecting the U.S. monitors is not specified in the HEU Transparency Agreement documents.

In 2010 we received the following radiological data from the plants:

- ECP – gamma exposure rates, surface alpha contamination, and airborne alpha contamination for each day of the SMV and for all SMVs;
- MPA –gamma exposure rates, surface alpha contamination, and airborne alpha contamination for each day of the SMV and for all SMVs;
- SChE –gamma exposure rates, surface alpha contamination, and airborne alpha contamination averaged for the 4 days of each SMV;
- UEIE –gamma exposure rates, surface alpha contamination, airborne alpha contamination, and neutron dose rates at the BDMS room averaged over a one-month period (we did not receive data for July and August since no U.S. monitors were present at UEIE).

The graphs in Appendix A (Appendix A is a separate C/FGI-MOD document) provide the gamma exposure levels and the airborne and surface contamination at the monitoring points and guiding action levels for each of the plants in 2010. A short discussion of the 2010 radiological data from the plants is included in Appendix A.

Detailed plant radiological data along with the action levels and the recommended precautions are included in each trip's Team Instructions Book.

Health physics support of the BDMS activities

During CY 2010 LLNL provided health physics support during the BDMS sources replacement at SChE, ECP and UEIE. LLNL provided support for the dose rate measurements around the Blend Down Monitoring Systems (BDMSs) for Russian regulatory compliance and support for neutron dosimetry to SChE, UEIE, the Russian Federal Nuclear Center - Institute of Technical Physics (VNIITF, C-70), and ECP.

Neutron and gamma dose rate measurements for regulatory compliance
A consistent dose rate measurement methodology for regulatory compliance is used in all Russian plants. This methodology improves the accuracy and allows a better comparison of measurement results from different years and different sources. The quality and the accuracy of the measurement results provide additional confidence in the source characteristics and their proper installation and manipulation. During the SChE, ECP and UEIE source replacement visits, detailed gamma and neutron dose rate measurements were performed at the surface and at one meter from all BDMS units with the assistance and in the presence of a U.S. health physicist. The measurement results were included in the radiation safety reports for the BDMS sources replacements.

Radiation safety reports for the BDMS source replacement
The radiation safety reports indicate that during and after source replacement the individual doses, as well as the gamma and neutron dose rates around the BDMS, did not exceed the Russian radiation safety limits. All plants applied regulatory limits that are based on the lower occupancy levels (less than 8 hr/day and 40 hr/week) in the BDMS premises. These less stringent limits allow six times higher radiation dose rates at 1 meter from the BDMS units and allow the use of stronger sources. The use of stronger sources benefits the HEU Transparency Program with substantial savings by eliminating the need for source changes through the end of the Program.

The UEIE Annex to the Purchase Agreement does not mention any radiation safety report or dose rate measurements during or after the BDMS source replacement. ECP and SChE HEU documents were negotiated after the difficulties experienced with obtaining a detailed radiation safety report from UEIE. Both ECP and SChE HEU Purchase Agreement documents state that upon U.S. request the plant shall provide "….the results of dosimetric confirmation measurements at the HEU-LEU blending area during the replacement of radioactive sources." In 2010 we received the following BDMS radiation safety reports:

- SChE - the report includes the data from each gamma and neutron dose rate measurement in the blending facility before, during and after the source change. The report states that the gamma and neutron dose rates, and the airborne concentration of uranium alpha particles are well below the Russian Federation regulatory limits. The removable surface contamination of the equipment and the floors does not exceed the background levels. The radiation safety report was signed by the Head of Radiation Monitoring Group at the Enrichment Plant and the U.S. health physicist. The report was provided to the U.S. during the next SMV following plant's security review.

- ECP - the report includes the data from each dose rate measurement and was signed by the ECP Head of Radiation Safety Service and the U.S. HEU health physicist. Air monitoring data for alpha and beta contamination, as well as for surface contamination at the blend point facility during the visit were below the Russian and the U.S. regulatory limits. These data were included in the report. We obtained the signed radiation safety report at the end of the source change visit.
- UEIE - the report includes the detailed dose rate measurement data and is signed by the UEIE Head of Radiation Safety and the UEIE health physicists involved in the survey. Measurements of the airborne alpha particles concentration, as well as, surface alpha contamination in the blend point facility during the visit were below the Russian and the U.S. regulatory limits. These data were included also in the report. The report was provided to the U.S. during the next SMV following plant's security review.

The BDMS radiation safety reports document that during and after source replacement the individual doses to all Russian and U.S. personnel involved, as well as the gamma and neutron dose rates around the BDMS, did not exceed the Russian Federation radiation safety limits and that all source replacement operations were conducted adhering to the ALARA (As Low As Reasonably Achievable) principle.

Relative Cf source measurements
LLNL assisted in the analysis of the data from californium sources relative measurements at the blend point locations and concluded that they are consistent with the data from the old (removed) californium sources and the source passports data. The relative measurements of the old (removed) and the currently installed californium sources at all plants provide assurance that the BDMS neutron sources are not a cause of any anomalies in the mass flow data. The source measurements data also provide a seamless continuation of quality mass flow data after the californium sources are replaced.

TV monitoring system and neutron detection equipment
The process of californium sources change and sources relative measurements were monitored with a remote video monitoring system. This technology allows a significant reduction of the radiation exposure to both the Russian and the U.S. personnel. The U.S. supplied neutron detection system (NDS) allows a substantial reduction of overall and per source measurement time. The LLNL-supplied TV monitoring system allows U.S. monitors and plant personnel to avoid unnecessary exposure while remotely observing source change and relative source measurement operations. Both systems are used to verify and confirm the source identity and neutron source characteristics. They were successfully used by VNIITF during source replacements at SChE, ECP and UEIE.

BDMS sources specifications
HEU health physicist provided assistance in developing the source specifications and ordering stronger sources which will allow longer intervals between source change campaigns. The specifications were developed in a manner to maximize the output and the reliability of the BDMS measurements and, at the same time, to comply with the Russian Federation radiation safety regulatory limits. The specifics of the dose rate

measurement instrumentation and treatment of measurement errors were taken into account in the development of the source specifications.

Bubble dosimeters
In 2010 LLNL shipped 60 bubble dosimeters with high sensitivity (~ 20-30 bubbles per mrem) to ECP, UEIE and SChE to support the BDMS sources changes (20 dosimeters per source change campaign). Prior to shipment of the bubble dosimeters to Russia, LLNL tested their calibration with a Cf-252 source (the manufacturer calibrates them with an Am-Be source) and, if needed, excluded any dosimeters out of tolerance. The bubble dosimeters are used to measure in real time the personal neutron doses for the involved plant, VNIITF and U.S. personnel. The bubble dosimeter information is valuable for the U.S. monitors and the Russian personnel as an immediate indication in case of a significant neutron exposure or radiation leakage from the BDMS shielding. The neutron dose information from the bubble dosimeters was included in the radiation safety reports for the BDMS source changes.

Information on HEU electronic information system (EIS)
The available data on EIS in the BDMS directory include two folders – BDMS Sources and Bubble Dosimeters for the use of the HEU community.

The BDMS Sources folder contains:
- All current and past Cf-252, Co-57 and Am-241 passports for UEIE, ECP and SChE BDMS sources
- Co-57, Am-241, and Cf-252 source specifications
- All radiation safety reports for the source change activities in English and the Russian originals for UEIE, ECP and SChE
- Tables of the detailed dose rate (gamma+neutron) measurements around the BDMS FM and EM units at UEIE, ECP and SChE for regulatory compliance
- Tables of the relative californium source measurements of the new, old, and the reference sources with any pertinent information for source changes and installations at the three plants
- Tables of the Cf-252, Co-57, and Am-241 source positions at UEIE, ECP, and SChE

The bubble dosimeter folder on EIS contains:
- Test results from the 2002 and 2008 certification of the bubble dosimeters by Doza (in Russian)
- 2003 and 2008 Bubble Dosimeter Accreditation certificate - original in Russian and the English translation
- Accreditation testing report and description - in Russian and in English

Reporting

In 2010 LLNL provided the following reports related to the health physics issues of the HEU Transparency Program activities:

- Post trip dose reports after each trip
- Quarterly bioassay (internal dosimetry) reports
- 2009 Annual Health Physics Report for the HEU Transparency Program
- 2009 Annual Occupational Dose Reports to each monitor that had a trip to Russia
- 2009 Annual Occupational Dose Reports to the POC for all monitors in his area
- Reports on various health physics topics requested by the HEU Transparency Program management

Conclusion

In 2010, the HEU Transparency Program activities in Russia were conducted in a radiologically safe manner for the HEU Transparency monitors in accordance with the expectations of the HEU Transparency staff, NNSA and DOE. The HEU Transparency Program now has over sixteen years of successful experience in developing and providing health and safety support in meeting its technical objectives.

Appendix A - 2010 Russian plants radiological data charts

Appendix A is a separate document that is marked C/FGI-MOD