RADIOLOGICAL CHARACTERIZATION OF V1 NPP BUILDINGS AND CIVIL STRUCTURES CONTAMINATION

Richard Hanzel[1], Tibor Rapant[1], Jaroslav Svitek[2]
1 - AMEC Nuclear Slovakia s.r.o., Piešťanská 3, 917 01 Trnava, Slovak Republic
2 – JAVYS a.s., Tomášikova 22, 821 02 Bratislava, Slovak Republic
richard.hanzel@amec.com

INTRODUCTION

V1 NPP at Jaslovske Bohunice site has been finally shutdown after 28 years of successful operation in 2006 (Unit 1) and 2008 (Unit 2). At present, both units (WWER type reactor 440/230) are finally shutdown and since July 2011 under decommissioning license. The preparation of V1 NPP decommissioning has been supported and partly financed by the Bohunice International Decommissioning Support Fund (BIDSF), under the administration of the European Bank for Reconstruction and Development. From 06/2008 to 12/2011 AMEC Nuclear Slovakia, together with partners STM Power and EWN GmbH, carried out BIDSF B6.4 project - Decommissioning database development (DDB).

B6.4 PROJECT CHARACTERIZATION

The main purpose of the B6.4 project was to develop a physical and radiological inventory database to support V1 NPP decommissioning process planning and performance. The following key project tasks have been established:

1. DDB design
2. Historical site assessment (HSA)
3. Documentation review and site survey resulted to Physical inventory
4. Measurement and sampling resulted to:
    - Hazardous material inventory
    - Radiological inventory including contamination and activation

AMEC Nuclear Slovakia was mainly responsible for DDB design, planning documents for physical and radiological characterization, implementation within the plant's controlled area of physical inventory, radiological site survey including sampling and analyses and at last characterization of activated equipment and civil structures based on measurement, sampling and analyses. In the sections below, a methodology, measurements techniques and summarized results from radiological characterization of external surface contamination and volume contamination of civil structures are described in detail.

RADIOLOGICAL CHARACTERIZATION PLAN AND IMPLEMENTATION

One of the part of the specific deliverable tasks within the B6.4 project was the characterization of external surface contamination and volume contamination of civil structures based on measurement, sampling and analyses performed on the samples. The scope of this specific deliverable task consisted of:

1. Specification of inventory scope
2. Development of radiological characterization plan
    - specification of methodology, monitoring and sampling plan
    - determination of contamination spread boundaries
    - categorization of database items
    - specification of radionuclide list for radionuclide vector (RNV) determination
    - definition of sampling and analyses techniques
3. Development of single working programs for radiological monitoring and sampling

4. Preparation of measurement and sampling devices
5. Determination of radiological parameters
6. Analysis of samples
7. Determination of radiological inventory including activity values, RNV and dose rates
8. Import of radiological data for contamination into DDB

Radiological characterization plan

Radiological inventory included nearly 100 civil buildings inside and outside of controlled area. Over 40 parameters have been defined for each DDB item, including identification, physical and radiological properties, etc.
Methodology, used in radiological characterization and described in radiological characterization plan, has been based on manual MARSSIM (Multi-Agency Radiation Survey&Site Investigation Manual). Plan in accordance with MARSSIM considered HSA and Scoping Survey results, defined Survey units and contained preliminary categorization of DDB items. ALARA and H&S principles have been used and QA criteria for measurement and statistical processing of data have been defined.
Monitoring plan for individual Survey units included number of measurements, sampling plan and selection of the most effective measurement and analyses types.
Contamination spread boundaries for buildings have been specified on the basis of HSA and Scoping Survey results. Main sources of area local contamination outside the NPP controlled area have been identified:

- leakage from boric acid tank and spent fuel storage pool (leak to underground water),
- treatment station of liquid industrial waste,
- temporary storage of contaminated equipment.

The list of radionuclides has been specified. For free release purposes the list included all identified artificial gamma emitters, and alpha and beta emitters typical for WWER reactors. For waste disposal purposes the list of radionuclides was supplemented by long-lived nuclides required by Slovak RAW repository.
Sampling and analyses techniques used in radiological characterization included dose rate measurements, direct measurements of surface contamination, on-site gamma spectrometry measurements, surface contamination sampling by wipe tests and scraping samples, liquid/sludge sampling, concrete drilling sampling and soil sampling. Laboratory analyses of samples included measurement of the total alpha, beta and gamma activity, gamma spectrometry analyses and radiochemical (alpha/beta) analyses of the samples.
Radiological parameters assigned to impacted civil structures included:

- dose rate in contact and at 1m distance
- external surface contamination
- volume/mass contamination

Radiological parameters assigned to rooms in controlled area included:

- average dose rate and maximum dose rate in room
- average surface contamination of floor and walls in room
- identification of hot spots.

Radiological survey outside the controlled area and NPP area survey

Radiological measurements in buildings outside the controlled area had been carried out as the first step of radiological survey in July/August 2009. The scope of survey includes:

- 320 direct measurements of dose rate,
- 680 direct measurements of surface contamination of walls and floors in individual rooms,

- 550 measurements of external surface contamination of equipment inside V1 NPP non-active buildings,
- 20 on-site gamma-spectrometry measurements.

From non-active buildings, 45 smears, scrapes and sludge samples had been taken for laboratory analyses.
Concrete sampling was individual part of the radiological survey in buildings outside the controlled area. It was performed by drilling from selected locations in buildings stated in sampling plan. These sampling activities were performed in December 2009 in accordance with the approved working procedure describing method and scope of works. In total, 8 samples of drilled concrete were taken. Diameter of samples was 38 mm and sampling depth was app. 200 mm. Concrete samples were subsequently cut into smaller cylinders with the thickness of 20-30 mm and analyzed by gamma-spectrometry.
V1 NPP area was divided to 10 sectors. 10 surface soil samples were taken from each sector and after homogenization one representative sample was prepared for each sector. Finally 10 samples were analyzed by granulometry and also gamma-spectrometry methods.

Radiological survey in buildings inside the controlled area

The scope of the radiological survey inside the controlled area was:

- 3400 direct measurements of dose rate in the individual buildings,
- 1465 direct measurements of surface contamination from walls, floors and external surfaces of equipment,
- 20 on-site gamma-spectrometry measurements.

Moreover, 1200 radiological laboratory analyses of external surface samples inside the controlled area have been carried out.
Concrete samples with the diameter of 38 mm have been drilled in 15 locations whereas each sample has been cut throughout its depth into 20 mm thick cylinders. This method helped to evaluate a contamination penetration into the concrete depth.
Data on external surface contamination of civil structures (walls, ceilings and floors) in individual room inside the controlled area have been obtained on one hand by direct measurements of surface contamination but on the other hand mainly by smear, scrap and drilled concrete sample analyses. Although both methodologies had been applied in approximately similar extent, it appears that the results from samples analyses were more determinative than direct measurement of contamination. The reason was that direct measurements of contamination were in many places affected by multiple sources of contamination in given room.

RADIOLOGICAL CHARACTERIZATION RESULTS

Results of radiological survey outside the controlled area

- 72 buildings outside the controlled area were determined as non-impacted without any contamination by artificial radionuclides.
- In 10 buildings (sink water purification plant, rain sewerage, cooling towers, waste and industrial water disposal, etc.) no contamination above the natural background level was detected during surface contamination and dose rate direct measurements, but the presence of artificial contaminants below the level 0,15 Bq/cm^2 was identified during the detail sampling and subsequent gamma-spectrometry analysis of samples.
- In 10 buildings (sewage and industrial drainage, Turbine hall, cross and longwise side electrical building, waste and industrial water disposal – safety and deoiling tank and sludge drying beds,

etc.) contamination above the natural background level was detected during direct measurements. The presence of artificial contaminants above the level 0,15 Bq/cm^2 or 0,15 Bq/g was identified within the detail sampling and subsequent gamma-spectrometry analysis of samples.

- Only local contamination areas have been detected in buildings outside controlled area of V1 NPP. Maximal activity levels of artificial radionuclides (up to 25 Bq/cm^2 of Cs-137) were measured in cross and longwise side electrical building. Contamination of the building parts on several locations within an area ranging from several square meters to tens of square meters was identified at these buildings. The above mentioned contamination was associated with boric acid leakage from the reactor building. The contamination was also confirmed in the concrete drill samples taken from walls and floors.
- No contamination by artificial radionuclides was measured in surface soil samples taken from V1 NPP area.

Results of radiological survey inside the controlled area

- Direct measurements values of dose rate inside the controlled area varied from background level 0,01 µGy/h up to 50 mGy/h.
- Direct total alpha contamination measurements of walls, floors and external surfaces of technological equipment discovered that these values were below the level of 0,03 Bq/cm^2 in all controlled area buildings.
- Direct total beta/gamma contamination measurements of walls, floors and external surfaces of equipment generally did not exceed 0,3 Bq/cm^2 value. Nevertheless, there also occurred some "hot spots" where total beta/gamma contamination values varied up to 46 Bq/cm^2. Majority of these "hot spots" were represented by sewage inlets and drain floor channels.
- Analyses of smear and scrap samples from external surfaces of walls, floors and technological equipment discovered that the maximum contaminations were located dominantly at sewage inlets or on leakages places of contaminated liquids in reactor building.

Determination of RNV for contamination

Results of gamma spectrometry of all samples for the purpose of RNV determination were statistically processed. Final list of RNV for contamination resulting from statistical evaluation of gamma spectrometry of samples included 2 RNVs, one for each V1 NPP Unit (some of civil structures have different RNV, like cladding of spent fuel pools, but amount of material is negligible). Final percentage of radionuclides for individual RNV was determined after radiochemical analyses of hard-to-detect radionuclides in selected samples.

CONCLUSION

Total radiological inventory of V1 NPP buildings/civil structures outside and inside the controlled area was 4,422E+10 Bq corresponding to total mass 2,297E+08 kg. Total radiological inventory recorded in DDB for civil structures outside the controlled area included only contaminated concrete material of cross and longwise side electrical buildings.

Radiological survey was carried out from April 2009 till May 2010 in compliance with MARSSIM methodology for preliminary radiological characterization. V1 NPP inventory process was finalized by recording of radiological parameters for equipment and civil structures in DDB. Resulting DDB represents a completed physical as well as radiological V1 NPP inventory.