

CLEARANCE WITH THE BERTHOLD MONITOR LB 2050

Alfred Klett¹, Alexei Krutjakow²

¹Berthold Technologies, P.O. Box 100163, 75312 Bad Wildbad, Germany

²Zentralstelle zur Behandlung und Beseitigung radioaktiven Abfalls des Landes Berlin, Glienicke Straße 10014109 Berlin-Wannsee, Germany

Summary: *Berthold Technologies has designed a new monitor for clearance measurements according to §29 of the Radiation Protection Ordinance. The mobile monitor has a sample volume of 150 liter and six large area sealed Xenon proportional counter tubes detect beta particles and gamma rays or X-rays. The detectors are covering approximately solid angle 4π and thus provide a very high sensitivity and an extremely good uniformity of the activity response, even for inhomogeneous radioactivity distributions in a barrel. A lead layer with thickness 5 mm reduces the background contributions.*

The barrels with radioactive waste can easily be loaded with a drawer. The sample's weight is automatically determined by internal scales. Data acquisition, analysis, visualization and storage in a database is performed by a personal computer. Labels for each measured barrel are printed with a label printer. The monitor is used by the central storage facility for radioactive waste in Berlin (ZRA) in the clearance routine since a couple of months. The monitor was calibrated with ⁹⁰Sr in a container type which is used by ZRA. More than 700 barrels were already processed. Calibration results and detection limits are reported

1. Introduction

Clearance is defined as the removal of radioactive materials within authorized practises from any further regulatory control [1]. In Germany clearance was newly regulated in §29 of the radiation protection ordinance [2]. There is "unrestricted clearance" and there is "clearance" with different sets of criteria in Germany. These are defined in attachment III table 1 of the radiation protection ordinance. The specified clearance levels comprise activity concentration and surface contamination values. This framework provides well defined guidelines also for manufacturers of clearance monitors and stimulated the design of a new instrument by Berthold Technologies.

2. Description of the Clearance Monitor Berthold LB 2050

The Monitor consists of a mobile detection unit with a measurement volume of 150 liter and an evaluation PC. Six large area gas-filled counter tubes view into the volume and measure both beta and gamma radiation. The sealed detectors are filled with Xenon gas and have a sensitive surface of 2000 cm² on the sides and 1000 cm² on top and bottom. The detector windows are protected by means of a grid. The approximate 4π geometry ensures a high sensitivity and a very good independence of the spatial distribution of the radioactivity in the waste container. The measuring chamber is clad with a 5 mm lead shield to reduce external radiation influence. The weight is automatically taken into account by means of an integrated load cell scale. The measurement data are collected in the PC and are stored into a data base.

The monitor can be preset for operation in semi-automatic mode by unskilled operators. The measuring chamber is loaded and unloaded ergonomically with a waste container or bag by means of a base plate mounted on two sliders. The measurement is started with a Start/Stop button. Status and result of the measurement are clearly indicated with 4 LED lamps. Information about loading condition, probe weight, validity of background values, etc. is automatically measured and calculated by the software. A skilled user can also operate the system directly from the PC and use the extensive software-tools.

3. Software Functions

The software program runs under WinXP or Win2000 on a commercial grade PC. All measurement data and results are stored in a MS Access data base. This approach ensures that customisation of the management and data storage system is relatively easy to implement. The software has following key features:

- User registration and management, password protected access
- Clearance measurement, protocol, printout on label printer
- Edit parameters for measurements and operating mode
- Background measurement
- Identification of sample
- Calibration (separate password)
- Data base retrieval

4. Conditioning and Clearance of Radioactive Waste at ZRA

Germany's federal state Berlin operates the Central Collection of Radioactive Waste Facility (ZRA - Zentralstelle zur Behandlung und Beseitigung radioaktiven Abfalls des Landes Berlin) as a department within the Hahn-Meitner-Institute. The ZRA is authorized to collect and store radioactive waste materials in solid and in liquid form which are generated in the federal state of Berlin. The total amount of collected solid waste was in the year 2004 approximately 35 m³. As the storage capacity is only limited, clearance is one of the main duties and responsibilities of the ZRA.

One important type of radioactive waste collected by the ZRA are materials with short-lived nuclides with half-lives below 100 days stored to decay. These waste materials are mainly generated by nuclear medicine or industry. The most important short-lived nuclides at ZRA include for example ³²P, ¹⁰³Pd, ¹²⁵I, ¹³¹I and ¹⁹²Ir. ZRA uses for these materials the so-called A50 barrel made out of polyethylene. It has a volume of 50 liter and the weight is typically 5 to 8 kg.

5. The Clearance Procedures at ZRA

The procedure for nuclear waste stored to decay comprises the following steps:

- The incoming inspection is performed by a measurement with a high resolution gamma spectrometer. The customer's characterization of the waste regarding composition of nuclides and activities is verified and corrected if necessary. Amendments have frequently to be applied.
- The waste barrels are then stored until the calculated activity concentrations are expected to be below clearance levels. This requires typically periods of 10 to 15 half-lives.
- Finally the waste barrels are measured with the clearance monitor Berthold LB 2050. If the measured values are below clearance levels the decision of

clearance is issued and the waste is discharged. Otherwise there will be further investigation by gamma spectroscopy. Based on these additional measurements clearance might be effected later.

Pure beta emitters wouldn't be measured during the incoming inspection, because gamma spectrometers are not sensitive for beta radiation. But the Berthold clearance monitor LB 2050 is capable of both, gamma and beta detection and would cover for pure beta emitters. Therefore it is calibrated to the reference nuclide ^{90}Sr .

The ZRA measured in the year 2005 more than 700 A50-barrels with radioactive waste. Approximately 90% of the barrels passed the measurement successfully and clearance could be immediately issued. The rest was investigated in more detail with gamma spectroscopy. In several barrels nuclides were found, which had not been declared. Occasionally these nuclides are radiochemical contaminations of the specified main nuclides. For instance ^{103}Pd is sometimes contaminated with ^{101}Rh or ^{102}Rh and ^{125}I could be contaminated with ^{126}I or ^{137}Cs . If the half-life of a contaminant exceeds the half-life of the main nuclide, the contaminant could become the dominating activity in the sample. Sometimes the activity concentration of the impurity exceeds even the nuclide specific clearance levels.

6. Calibration and Minimum Detectable Activity Concentrations

Calibration should be made with the used container and isotopes in a representative waste matrix. The waste matrix very often consists of lightweight materials tossed loosely together. For calibration at ZRA a A50 barrel was filled with equal shares of glass and plastic vials, pulp, filter paper and protective gloves. A radioactive $^{90}\text{Sr}/^{90}\text{Y}$ source with total activity 4689 Bq was assembled in the central position of the calibration barrel. The total weight of the calibration barrel was 5.5 kg. The counting rates of the detectors were measured and the mean detection efficiency was determined to be 0.307%.

The measuring periods for background and sample measurement are 600 s and 120 s respectively. With these measuring times the minimum detectable amount of activity concentration of $^{90}\text{Sr}/^{90}\text{Y}$ amounts to 0.6 Bq/g. This is far below the clearance level 2 Bq/g for unrestricted clearance or for clearance, which is for this nuclide the same.

7. Discussion

The new clearance monitor Berthold LB 2050 provides fast and reliable measurement of activity concentrations in radioactive waste barrels. The ZRA has already processed during the year 2005 more than 700 solid waste samples with short-lived radionuclides. There was a considerable amount of wrong declarations and contaminants found. Therefore measurements of activity concentrations after storage for decay is mandatory. Clearance based only on decay calculations would fail in too many cases.

8. References

- [1] Safety Guide, Applications of the Concepts of Exclusion, Exemption and Clearance, IAEA, Vienna, RS-G-1.7, 2004
- [2] Radiation Protection Ordinance, July 20, 2001, Bundesgesetzblatt 2001, Part I, p. 1714