

## **Karlsruhe Database for Radioactive Wastes (KADABRA) - Accounting and Management System for Radioactive Waste Treatment - 12275**

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### **ABSTRACT**

The data management system KADABRA was designed according to the purposes of the Central Decontamination Department (HDB) of the Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH (WAK GmbH), which is specialized in the treatment and conditioning of radioactive waste. The layout considers the major treatment processes of the HDB as well as regulatory and legal requirements. KADABRA is designed as an SAG ADABAS application on IBM system Z mainframe. The main function of the system is the data management of all processes related to treatment, transfer and storage of radioactive material within HDB. KADABRA records the relevant data concerning radioactive residues, interim products and waste products as well as the production parameters relevant for final disposal. Analytical data from the laboratory and non destructive assay systems, that describe the chemical and radiological properties of residues, production batches, interim products as well as final waste products, can be linked to the respective dataset for documentation and declaration. The system enables the operator to trace the radioactive material through processing and storage. Information on the actual status of the material as well as radiological data and storage position can be gained immediately on request. A variety of programs accessed to the database allow the generation of individual reports on periodic or special request. KADABRA offers a high security standard and is constantly adapted to the recent requirements of the organization.

### **INTRODUCTION**

The Central Decontamination Department (HDB) of the Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH (WAK GmbH) is specialized in handling radioactive wastes and residues from decontamination and recycling to conditioning for final storage. For this purpose a variety of methods for the treatment and conditioning of wastes with low and intermediate activities are available such as decontamination, compaction, incineration, evaporation and cementation.

Meeting the guidelines for the treatment of radioactive waste and the final storage of the waste packages stated by the authorities and the repositories management requires extensive measurement techniques. HDB applies a multi-purpose radiochemical laboratory for analysis of radioactive samples, a variety of drum measurement systems as well as a release measurement facility.

The handling of radioactive materials, including radioactive wastes, obliges to compliance with regulations such as the Atomic Energy Act [1], the Radiation Protection Ordinance [2], waste acceptance criteria for final disposal [3] etc. The German Radiation Protection Ordinance requires the accounting of radioactive wastes in terms of mass, radiological and physical composition in an electronic database to provide comprehensive information to the appropriate authority upon request. The system must be authorized by the appropriate authority.

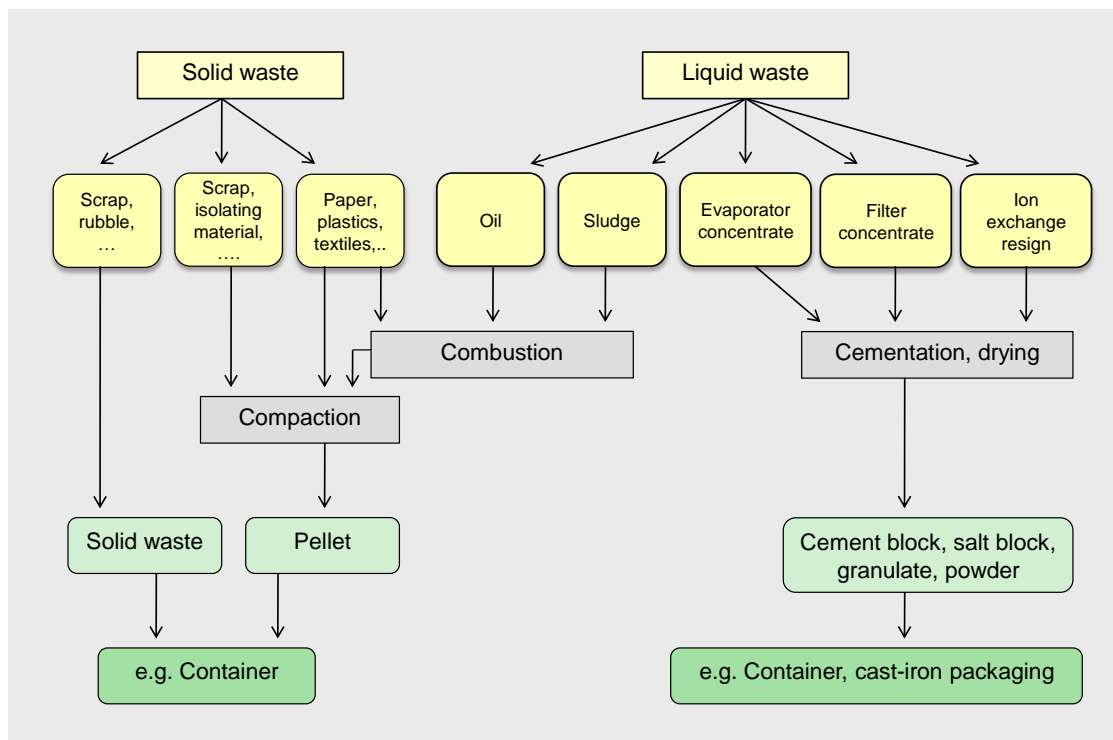


Fig. 1: Treatment of different kinds of waste

For this purpose HDB has designed the special computing software **KADABRA** (**K**arlsruher **D**atenbank für radioaktive **R**eststoffe und **A**bfälle – Karlsruhe database for radioactive wastes) which collects and documents all relevant data according to the valid requirements. In addition to the accountability of radioactive material the main function of KADABRA is the data management of all processes related to treatment, transfer and storage of waste within HDB.

## TECHNICAL DETAILS

KADABRA is a modular ADABAS-application (Adoptable DATAbase, a SAG product) composed of a large variety of programs written in the program code "Natural", which are arranged in sequences to perform the desired operations. The programs encompass 2.6 million lines of code in total. 12,000 functions, modules and programs control about 26 million records.

The database is operated on an IBM Z10 mainframe E10 with a DS6800 1.2 Terabyte hard disc. On the mainframe three virtual machines are in operation under Z/VM6.1 /Z/VSE:

- the production machine, which manages and stores the actual data
- the test machine, identical to the production machine, allows program development under real conditions
- the calculation engine, mainly used for large scale decay calculations and other complex simulations.

A back-up of the data and the programs is carried out daily, a back-up of the entire operation system once a week. The back-ups are performed and stored in two independent places to remain operational even in the case of a major accident. In this case the database can be run in a second data processing centre and accessed directly or remotely.

The security is granted by the fact that KADABRA runs on a stand alone machine and the operations are performed on terminal functions, which run on the office PC over a second system.

## FUNCTIONS

KADABRA fulfills a variety of functions which are depicted in figure 2 and explained in the following chapters.

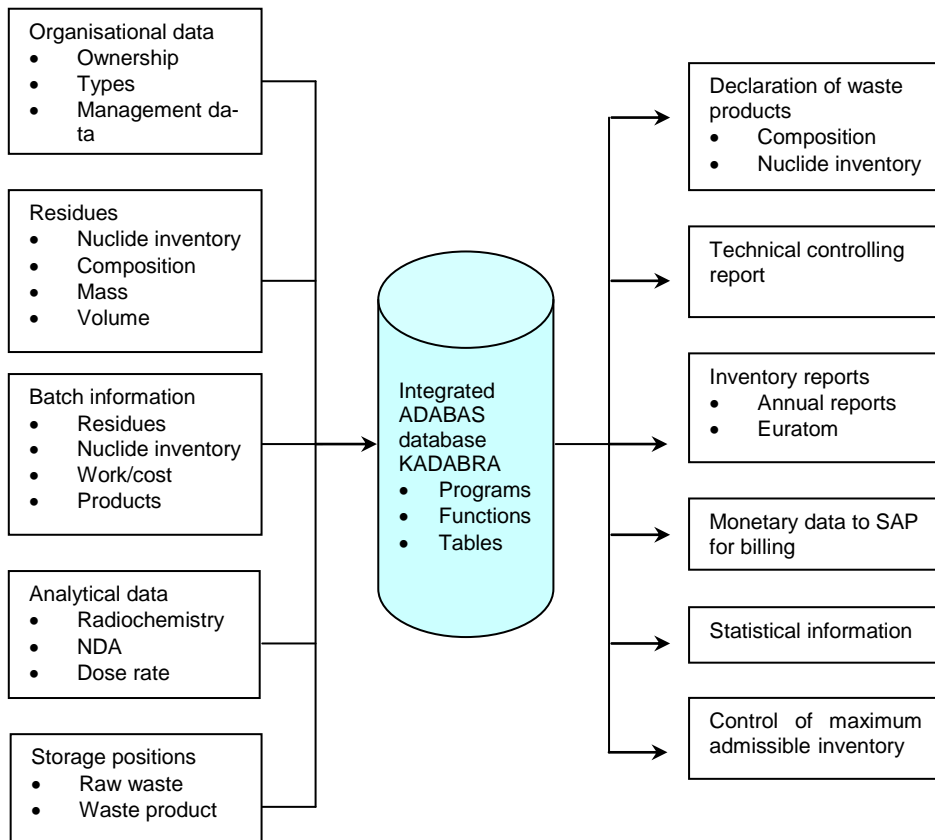


Fig. 2: Functional concept of KADABRA

The input data (left) are stored and computed to yield the output data (right) generally used for reports and control functions.

### **Collection and documentation of all relevant data of radioactive residues according to the valid acceptance criteria of the HDB facilities**

The German Radiation Protection Ordinance comprises the obligation for accountancy when handling radioactive wastes. Furthermore, waste acceptance criteria [4] based on specific facility requirements and activity limits have to be observed when delivering radioactive waste to HDB. For this reason the waste has to be specified on an individual dispatch note, which has to be subject to a preliminary check at HDB prior to waste delivery.

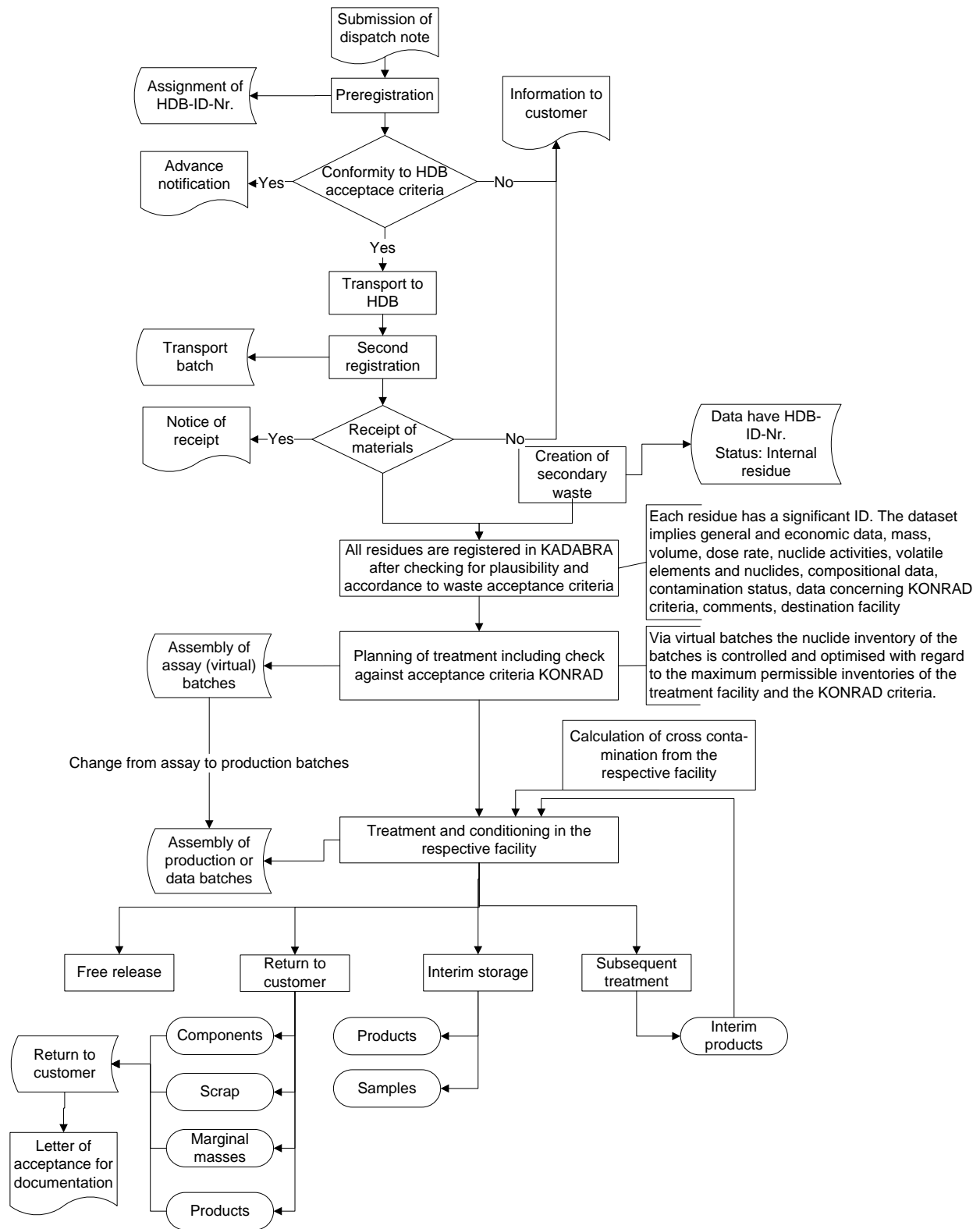


Fig. 3: Flux of material and data through the HDB facilities

The dispatch note for radioactive residues includes data as e.g.

- residue ID number according to the Radiation Protection Ordinance
- information on customer, material producer and owner
- package (external container, inner packing, over pack for transport or shielding purposes)
- designation and description of the residue
- mass, volume, dose rate and contamination
- activity inventory (total activity, individual nuclides and fissile materials)
- determination and distribution of activity
- information on special residue (residues, whose activity concentration or activity inventory, inner packaging, external container, dose rate and/or surface contamination do not comply with the HDB acceptance criteria), hazardous substances as well as on basic requirements of the repository acceptance criteria (freely movable liquids, closed vessels, self-igniting substances, explosive substances, putrescent and fermentable substances, solid or solidified, percentage of activity in the form of combustible constituents with a melting point of  $< 300^{\circ}\text{C}$ )
- chemical substances that may affect the ground water in any way.

The dispatch note can be transmitted either in printed version or electronically via ASCII-code. To generate the electronic data sheet any customer-specific software or the KAReE residue acquisition system, a Microsoft ACCESS application distributed by HDB, may be used. Secondary waste or demolition waste produced by HDB-internal facilities is directly entered in the KADABRA documentation system via a data acquisition dialogue by the waste producing facility. While entering the data the software (KAReE as well as KADABRA) guides the user to avoid misunderstandings and mistakes. Individual nuclide vectors which are stored in the database allow an unproblematic declaration of radioactive residues on the basis of dose rate values or analytical results.

The completed data sheet is forwarded for review. If the waste and the documents comply with the acceptance criteria the material may be delivered to HDB. Otherwise the data have to be corrected prior to acceptance.

Radioactive wastes that are announced for delivery are entered into a transport batch which allows a check of the transport data and permissions. Following the data check the program prepares all relevant documents for transportation and information of the authorities. Upon arrival at HDB the waste containers are booked into the KADABRA database and subsequently subjected to an entrance control, which comprises mass, volume, dose rate and nuclide inventory by  $\gamma$ -spectrometry. The data of these measurements are compared with the declaration. In the case of deviations the customer is requested for correction.

### **Control of permissible values in terms of permissions and transport regulations**

The handling of radioactive waste at HDB takes place within the scope of a comprehensive permission which includes activity limits for each individual facility. Beside of these restrictions limit values for emission of volatile nuclides as well as total alpha and beta activity have to be observed while handling radioactive waste. In order to fulfil the requirements and to make sure, that neither activity limits nor permissible emission values will be exceeded, all individual limit values are deposited in KADABRA. The acceptance of radioactive waste as well as any transfer of radioactive material within the HDB requires a conformation check of the individual waste data to the limit values taking into account the actual inventory.

Planning a waste treatment campaign the production batches are calculated as virtual batches in KADABRA first, in order to check the compliance with the waste acceptance criteria of the final repository and the actual transport regulations. After verification of concordance the batch is transferred into a production batch and the residues are physically transferred to the treatment facility.

### **Accountancy of fissile material according to the regulations of the European Atomic Energy Community (EURATOM) and the International Atomic Energy Agency (IAEA)**

The shipment of wastes containing fissile materials to HDB and from HDB to other customers is documented and reported to EURATOM monthly according to EURATOM Regulation 302/2005.[5]

The data for documentation and reporting as for example

- material balance area (MBA)
- categories of nuclear material (plutonium, depleted uranium, natural uranium, low enriched uranium, high enriched uranium, thorium)
- batch designation
- material description (codes that are composed of the type of material, the material container, and the state of the material)
- type of measurement (basis on which the quantity of the nuclear material declared was determined)
- number of items
- obligations (e.g. Material subject to the EURATOM/USA collaboration agreement)
- mass of the elements

are extracted from the dispatch note of the radioactive residues and administrated in KADABRA.

The data for the monthly inventory change report as well as for the annual material balance report and the physical inventory listings are generated by KADABRA and transferred to the data format requested by the supervision authorities.

### **Determination of the waste treatment strategy**

The waste is treated in batches planned and assembled on the base of similar materials and nuclide inventories taking into account:

- the maximum permissible nuclide inventory of the individual treatment facilities stated in the HDB permission
- the release of volatile nuclides during waste treatment, such as H-3, C-14 and I-129
- the waste acceptance criteria for final disposal
- customer specific parameters and obligations
- economic criteria.

### **Tracking the waste during conditioning**

Recording and documentation of all waste treatment steps guaranties the traceability of the material from the original waste producer to the final waste product, which is demanded by the German Radiation Protection Ordinance. Pre-treatment steps such as sorting, decontamination, pre-compaction etc. are documented in pre-treatment batches. A sequence of pre-treatment batches may be performed prior to final conditioning. As a consequence a variety of interim

products with different material and nuclide composition and ownership are produced. The sequences of successive and branched batches are finally assembled in production batches. KADABRA functions calculate and document the compositional and radiological inventory and the activity flux during the conditioning process.

### **Recording of treatment parameters and analytical results**

The relevant data needed for declaration and specification of the waste products and for the product documentation according to the final repository acceptance criteria are produced either in the appropriate production facility (mass, dose rate, process parameter), by non-destructive assay systems (dose rate, mass,  $\gamma$ -nuclides) or in the laboratory (radiological and chemical specification). The relevant data are transferred to KADABRA via a standardised interface or an import function.

This documentation also comprises all relevant data for the KONRAD repository defined in the product control regulations. Products for the repository KONRAD have to be conditioned according to qualified techniques and have to meet defined quality standards depending on waste type, KONRAD product group and container type. In the process of batch planning the waste product group (e.g. product group 4 for super compacted pellets with less than 5 % combustible material) is defined by the operator. The related quality parameters have to be recorded during the conditioning process, a function also provided by KADABRA. In the future the proofs of quality and process relevant documents will be incorporated as scanned files in an attached database.

### **Declaration of waste products**

KADABRA allows several approved calculation procedures of nuclide inventories of production batches and individual waste products. The most common procedures are:

- calculation of nuclide inventory per drum on the basis of dose rate measurements:
  - a) the nuclide inventory of the batch is allotted to the individual drums in relation to their dose rate values.
  - b) the nuclide inventories of the waste products (drums) are recalculated on the basis of their dose rate values and the nuclide composition (nuclide vector) of the batch.  
→ This procedure is normally applied for large batches of compacted waste.
- pellet tracking: the declared inventory of each pellet in a batch is recorded and the inventory of a waste product is calculated by the sum of the pellets in the drum.  
→ This procedure is especially designed for the compaction and is applied if the content of each pellet has to be declared.
- calculation on basis of analysis, batch inventory and mass of the waste product: detectable nuclides are analysed in the laboratory by different analytical methods as gamma spectrometry, alpha spectrometry etc. Not detectable nuclides are added from the batch vector related to a defined key nuclide (e.g. Co-60, Cs-137). The obtained mass specific results are used to declare the nuclide activities of the waste products on basis of their individual mass (e.g. concentrate added in each drum for solidification).
- calculation on basis of analysis, batch inventory and dose rate: the nuclide composition is determined by analysis and correlation as described before. The inventory is assigned to the individual drums via dose rate values.  
→ This method is applied for the calculation of the inventory of bottom ash from the incinerator, which is super compacted in a second step.

In addition to the nuclide inventory resulting from the processed waste in the individual batch cross contamination from batch to batch has to be considered. This cross contamination is calculated as a defined small fraction of the batch inventory and is transferred to the subsequent batch.

### **Measuring and billing of waste treatment costs**

Prior to the delivery of radioactive wastes to HDB a valid contract specifying the boundary conditions of conditioning including the charges is required for each customer and residue. Contract details relevant for treatment and billing, as for example the contract number, cost unit, customer and owner of the material, as well as specifications for treatment of the material, are stored in KADABRA.

Costs for the treatment of individual wastes are determined in the treatment facilities on time or on material basis and documented in KADABRA. The costs are booked directly at expense of the individual waste products or, if the costs cannot be related to an individual product, of the contract, alternatively. Monthly the data are transferred via office communication software to an SAP-System for billing.

### **Additional tools**

- KADABRA offers tools to ease the planning of treatment, packaging, storage and transport of radioactive residues and waste products.
- To be able to calculate the actual amount of radioactivity a decay calculation program provides decay functions as well as full decay chains of complex nuclide spectra.
- The calculation of specific nuclide inventories by analysed dose rate or the expected dose rate on the base of an given nuclide spectrum are performed by conversion factors produced by Monte Carlo codes and kept in the database in specific tables.
- The transport function allows the calculation of appropriate transport containers as well as the respective transport category according to the European agreement concerning the international carriage of dangerous goods by road.
- The management of analytical data resulting from laboratory analyses or non destructive measurement systems allow the calculation of nuclide inventories from radioactive wastes to final waste products.
- A variety of programmes related to KADABRA are available for the generation of individual reports on periodic or special request.

The program functions of KADABRA are constantly changed and upgraded according to the administrative and legal requirements. The change management is monitored by the management and the authorities.

### **FUTURE DEMANDS / DEVELOPMENTS**

The license under the Water Management Act of the approval notice for the KONRAD repository [6] limits the mass of numerous groundwater-relevant substances according to legislation [7-9]. These substances have to be declared by the waste producer or conditioner taking into account the description threshold values of the waste packages to be disposed of and to be balanced by the Federal Radiation Protection Authority (BfS). Declaration is based on a list of ap-



proved substances updated by BfS. This list compiles elements and compounds hazardous to groundwater, which may possibly be contained in the waste packages to be disposed of. For the description of the chemical constituents of substance mixtures, so-called “substance vectors” may be used. These vectors are composed of individual compounds listed in the list of approved substances and reflect the chemical composition of defined substance flows or waste products. KADABRA offers different functions to collect data on the chemical composition of radioactive residues. For the declaration of the resulting waste products substance vectors with defined compositions e.g. for ashes, compacted mixed wastes, or evaporator concentrates shall be utilized. In addition the chemical composition of waste drums and containers has to be regarded, when declaring a waste product for final disposal.

A possibility for tracing of chemical substances while processing radioactive residues and intermediate products is actually not included in KADABRA. Mode and extend for program upgrading, that will be required, have to be cleared with the authorities responsible for final disposal.

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