

DECOMMISSIONING OF FOUR GERMAN FUEL CYCLE FACILITIES

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ABSTRACT

The decommissioning of four Siemens fuel cycle facilities is described in this paper. Three fuel fabrication plants – two for uranium and one for MOX fuel assemblies – and a hot cell research complex are in various stages of decommissioning. All the buildings of one facility have already been handed over to a new operator for non-nuclear production after a 6-year decontamination and clearance procedure. Special problems, techniques, methods of measurement and experience associated with these decommissioning projects are outlined. A description of waste management, mainly dealing with α -waste, and examples of cost optimization are also provided. Ten years of practice in decommissioning and dismantling provide a unique platform of experience. Finally, the paper outlines the possible application of know-how and equipment from the larger MOX fabrication facility, which never went into operation, for conversion of ex-weapons plutonium in Russia.

INTRODUCTION

Following the decommissioning of a number of German nuclear power plants as well as the Karlsruhe reprocessing plant, the decommissioning and dismantling of Siemens' former facilities for the fabrication of uranium and mixed-oxide (MOX) fuel assemblies in Hanau-Wolfgang and Karlstein will mark the disappearance of another significant portion of Germany's nuclear fuel cycle. The projects also include decommissioning of the hot cells in Karlstein, closed down in 1989, in which Germany's most extensive post-irradiation investigations of fuel assemblies and materials had been carried out since 1967.

The decisions to permanently shut down these facilities were taken in the early to mid-1990s. The main factors leading to these decisions were the political situation prevailing at that time in Germany, especially in the state of Hesse, but also to a certain extent economic considerations.

The fabrication of uranium- and gadolinium-bearing fuel assemblies at Siemens' Karlstein Fuel Fabrication Plant (previously KRT GmbH) was abandoned in 1994/95. Up until then, since its founding in 1966, the plant had processed around 3000 Mg of UO_2 to make 870,000 fuel rods. At the uranium processing facility of Siemens' former Hanau Fuel Fabrication Plant (previously RBU GmbH), around 13,000 Mg of UO_2 and 5 million fuel rods were fabricated in the period between 1969 and 1995. The neighboring MOX processing facility (formerly ALKEM GmbH) has processed 8.5 Mg of plutonium to make 26,000 fuel rods since its founding in 1965 at the former Karlsruhe Nuclear Research Center and since 1970 in Hanau.

Each of these facilities is in itself unique. The hot cells are special in terms of their radioactive content, characterized by very high activity levels and correspondingly high dose rates. At the fuel fabrication plants that have been processing uranium and plutonium, only alpha emitters with their low clearance levels have to be measured for the release procedure. An additional aspect requiring consideration in the case of the uranium facilities is that they were designed more than 30 years ago – on the basis of completely different licensing requirements – for "open" handling of uranium, i.e. without provisions for local confinement, throughout large areas within the facilities and were operated in this way for many years. Of course this had consequences in terms of the degree of contamination inside the fabrication buildings as well

as outside the facility. Moreover, all of the facilities have been the focus of heated confrontations with a few but very active portions of the population and certain political parties in recent years. The conflict surrounding plutonium processing was and still is particularly intense.

LICENSING PROCEDURE

The German Atomic Energy Act does not make any significant distinction between the erection or decommissioning of nuclear facilities. Neither Siemens nor the licensing authorities and their independent experts had any directly applicable experience in this field. Extremely slow and tedious discussions were sometimes necessary in order to arrive at a mutually agreed procedure regarding license application documents and project performance. An especially difficult topic in this connection was and still is the definition of acceptable limits for the decontamination and release of facility equipment, building structures, building rubble and soil, including measurement and verification of residual contamination levels. One of the reasons for this is that, for nuclear facility decommissioning, not just nuclear licensing requirements play a role, but requirements set forth in non-nuclear building codes and water and waste management legislation are also steadily gaining in importance. The duration of the licensing procedures – i.e. the time from submittal of a license application to issuance of the license – was around 1½ years for those procedures for which the licensing authorities required a public hearing. These public hearings, although not mandatory, were conducted at the authorities' discretion, probably solely on account of the already mentioned political volatility of these particular procedures and the public attention focused on these facilities. In addition, the authorities also required that an environmental impact statement be prepared, although this is not mandatory by German law.

The licensing situation as well as the operating status of the four facilities prior to decommissioning differed considerably. The hot cells and the uranium processing facility in Karlstein had valid operating licenses under the Atomic Energy Act and their equipment met the licensing requirements in full. This meant that once the decision had been made to permanently shut down these facilities, cleanout of all nuclear fuel materials from the facilities could proceed immediately under the terms of their operating licenses.

The situation was different in the case of the two fuel fabrication plants in Hanau. The two facilities had also been granted construction permits and operating licenses, but these had not been fully implemented.

In the uranium facility, necessary backfitting of certain production equipment had not yet been completed. Moreover, the explosion of an offgas scrubber in December 1990 resulted in the chemical section (UF₆ conversion plant) no longer being in operation. Therefore the equipment which was needed for processing and cleaning out polluted uranium solutions was not available. The basic prerequisites for being able to process such residual materials in the old production facilities first had to be created in conjunction with the decommissioning licensing procedure. Release of the site of the uranium facility has proved to be a particularly difficult undertaking from a licensing standpoint. Because of the way, mentioned above, in which uranium had been handled there in previous years in accordance with the practices common at that time, the soil surrounding the buildings was contaminated, with a total activity of up to 4 Bq/g in some locations. In the course of remediation in the late 80s, around 60% of the site was decontaminated to an average residual uranium contamination of 0.2 Bq/g. In addition, samples of the groundwater taken from a well directly adjacent to the fabrication building have revealed somewhat elevated uranium levels originating from leakages in wastewater channels. There is no question that part of the soil will have to be removed and disposed of. However, it has not yet been possible to arrive at an agreement with the licensing

authorities as regards a final contamination limit for the remaining soil or groundwater. Rapid conclusion of this procedure is being further hindered by the fact that not only the nuclear licensing authorities, but also the local water authorities are involved. Hence, not only the radiological exposure pathway has to be considered along with its limit, but also exposure pathways associated with the chemical toxicity of uranium, both for humans and for smaller life forms present in the water (e.g. microfauna). Based on the very restrictive approach due to consideration of ecological toxicity, a value of 2 μg uranium per liter groundwater was calculated by the authority (the natural value is around 1 $\mu\text{g}/\text{l}$). For humans, values of up to 25 $\mu\text{g}/\text{l}$ are regarded as being tolerable. Our plans are to decontaminate the soil as far as reasonably achievable, aiming at a target value of somewhat less than 20 $\mu\text{g}/\text{l}$.

Actually, the MOX processing facility was supposed to have moved years ago to a new fabrication building located in the immediate vicinity. This building, for which a construction permit and operating license had been granted, was 95% complete and met all safety requirements associated with internal and external hazards, radiation protection and physical security, etc. But the move never took place. In June of 1991, following a radiologically insignificant event, the authorities demanded that the old MOX facility be shut down. Approval for operation to be resumed also failed to be given in the years that followed. This meant that a fully operative production line was brought to a standstill from one day to the next, leaving an inventory of 2.25 Mg of plutonium in various stages of processing. Since the old MOX facility had been meant to serve only as a testing facility and workshop following startup of the new building, the licensing authorities were of the opinion that the old MOX facility was no longer in possession of a construction permit and operating license under the Atomic Energy Act. Especially difficult and tedious discussions were therefore required to convince the licensing authorities that cleanout of the facility could only be reasonably performed within the old facility, using the service-proven fabrication equipment and the existing experienced personnel, and that this would also be acceptable from a safety standpoint. Cleanout of the MOX facility was finally able to be started in October 1997, 16 months after license application. A total of three partial licenses were issued for the cleanout operation, covering backfitting of the requisite systems and equipment, shutdown of fabrication equipment no longer needed, and actual cleanout itself.

TIME SCHEDULE AND COSTS

The time schedule for all of the decommissioning projects (Fig. 1) provides an overview of the progress that has been made so far since the start of cleanout and shows the activities that remain, as well as the ultimate goals of the projects.

The costs for the licensing and supervisory procedure, expert opinions, monitoring, documentation, the actual decommissioning activities themselves, intermediate and final waste storage are estimated to be roughly DM 1.4 billion. This figure does not include the costs for cleanout of the MOX facility.

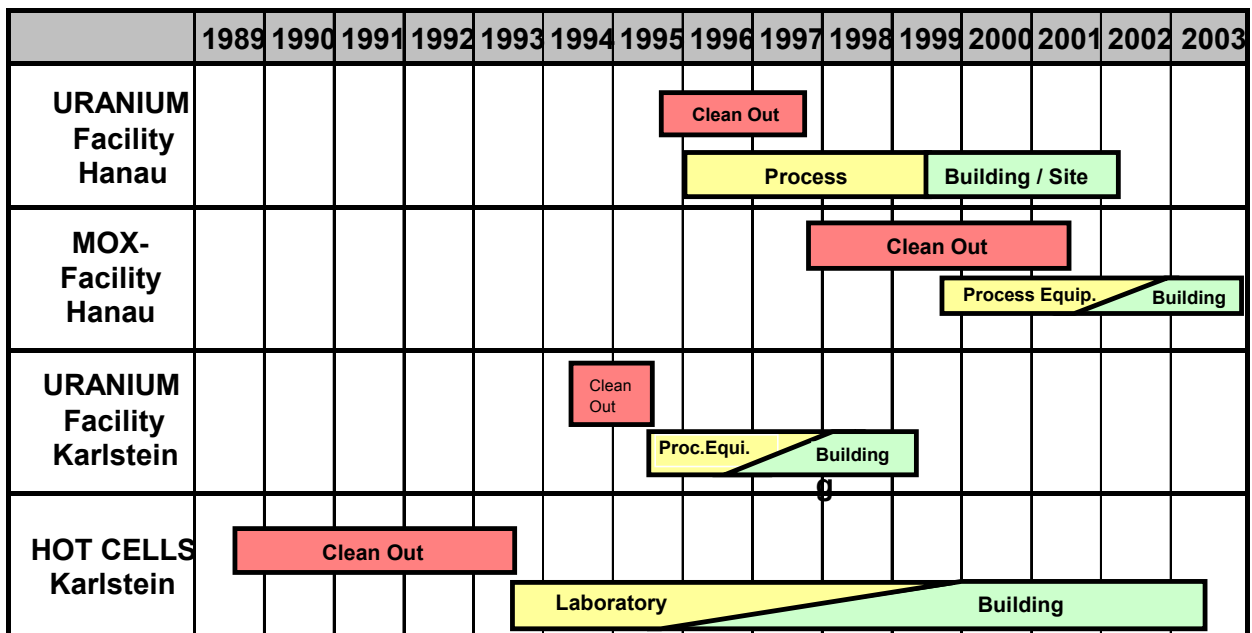


Figure 1: Decommissioning time schedule of the four nuclear facilities

The cost of the above-mentioned licensing procedure for cleanout of the MOX processing facility came alone to DM 11 million, of which DM 9 million were for the services provided by the authorized inspection agencies and DM 2 million for licensing fees.

A total of 2000 jobs will be lost at Siemens, along with another 1000 in the supply industry.

STAGES OF DECOMMISSIONING

The decommissioning of all four facilities proceeds more or less in the following stages, which are distinctive from both a technical and a licensing viewpoint:

- Shutdown of fabrication equipment which has no further function.
- Backfitting and modifications in the existing facilities.
- Facility cleanout to remove all nuclear fuel materials.
- Dismantling of production equipment for transportation to other nuclear facilities.
- Step-by-step dismantling of all equipment in the radiation protection areas, together with dismantling and disposal of all process systems.
- Decontamination of work areas and measurement of contamination levels for release, as well as removal of interior room and building structures.
- Decontamination of the remaining building structures and measurement of contamination levels for release, and release of the buildings for demolition or for non-nuclear use.
- Dismantling of auxiliary and support systems and dismantling of remaining physical protection equipment and barriers.
- Restoration (if required) and release of the site.
- Release of the facilities from being subject to supervision under the Atomic Energy Act.

Cleanout of a facility is generally the first stage in its actual decommissioning, as can be seen from Figure 1. Most of the remaining nuclear fuel inventory in the uranium processing facilities was shipped to other nuclear facilities belonging to Siemens in Germany and abroad. The plutonium inventory of the MOX processing facility is first being processed in the special cleanout program already mentioned, such that it is then suitable for long-term storage, suitable for shipment and meets the material receiving specifications of the external recipients (e.g. Cogema and BNFL).

DECOMMISSIONING OF URANIUM PROCESSING FACILITY IN KARLSTEIN

Decommissioning of this processing facility was concluded as the first of the four projects on March 31, 1999 with release from the Atomic Energy Act, six years after cleanout had been started. The decommissioning goal was to release the buildings for further non-nuclear use. The decontamination work, contamination measurements for release, verification measurements by the authorized inspection agencies (totaling around 400,000 measurements) and documentation were correspondingly extensive.

One of the special features of this project was that structural components for fuel assemblies were also being manufactured in this building. This non-nuclear production line was to be disturbed as little as possible by decommissioning of the nuclear sections and was to remain in operation both during and after dismantling of the nuclear sections. Consequently work overnight and at weekends was necessary.

New surfaces were created for decontaminating the buildings. On ceiling and wall structures, some of which were of an extremely complex geometry, needle guns were used to remove an approximately 5-mm-thick layer from the surface, equivalent to double the penetration depth of UO₂ powder. Paint on steel structures was either stripped using chemicals or removed by blasting. Floor toppings were completely removed.

All cracks in the building structures, anchor bolt holes, recesses for electrical outlets and concrete expansion joints were treated separately and, in most cases, removed to twice their initial depth and diameter.

In some cases, new measuring systems were developed for contamination release measurements and verification measurements on complex or large-surface building structures. For example, a new large-area counter (0.5 × 1 m) that had been qualified by the authorized inspection agency was used to measure the contamination at an approximately 1-m-deep building expansion joint.

For contamination verification measurements on walls, ceilings and floors, the authorized inspection agency qualified an in-situ measurement technique based on gamma spectrometry. The detector is equipped with a collimator and enables up to 5 square meters to be measured at one time, depending on the collimator angle and the distance of the measuring instrument from the surface. Depending on the density of the material, activity levels in building structures can be measured in surface layers that are 20 to 50 mm thick. Until then, this technique had only been employed for measuring gamma-emitting nuclides in nuclear power plants and was now deployed for the first time in a uranium processing facility. Despite the delay and additional costs caused by qualifying this technique while decommissioning was in progress as well as by the discussions regarding correct interpretation of the measured data, use of this in-situ measuring technique ultimately contributed to reducing the time needed for these verification measurements.

DECOMMISSIONING OF URANIUM PROCESSING FACILITY IN HANAU

Operation of this facility was stopped, as planned, on September 30, 1995. During cleanout, around 700 Mg of uranium and residual fabrication materials in various forms, although primarily UF₆, were shipped off site to other nuclear facilities.

However, in addition to these residual fabrication materials, large quantities of polluted uranium-contaminated intermediate products left over from earlier fabrication campaigns were

also present at the time of shutdown, such as UF₆ cylinder flushing solutions, sludge from production equipment flushing and sludge contaminated with iron from final process system cleanup. During fabrication, these products had been intermittently treated in the chemical section (UF₆ conversion plant) and the recovered uranium returned to the process. However, this treatment path was no longer available since the above-mentioned explosion of an offgas scrubber in the chemical section. It was therefore not possible to recover the uranium in an economical manner. Hence these products have to be entirely disposed of as radioactive waste.

Some large components such as pellet presses, pellet grinding machines, sintering furnaces, equipment for pellet stacking, and component assembly and laboratory equipment were cleaned, dismantled and shipped to other nuclear facilities for reuse. The recipients included facilities which already used Siemens technology (in Brazil and Argentina), but also fuel fabrication plants operating with their own technology. Most of the process equipment, however, was cleaned, dismantled, sectioned and packaged in 200-liter drums. The licensing authorities issued a total of 14 separate licenses for these activities, enabling all of the production systems to be decommissioned and dismantled.

Following a public hearing, the first partial license was issued on July 30, 1999 – 17 months after it had been applied for. This license covers dismantling of the auxiliary and support systems as well as decontamination and demolition of certain buildings. Work on completing these tasks will continue in the coming months. A second partial license – for the demolition of further buildings – is expected to be granted in February 2000. The third and final partial license covering dismantling of the baseplates of the buildings and decontamination of the site is expected for mid-2000.

Work was started at an early point in time on characterizing the contamination and activity levels in all building structures. These surveys accounted for all kinds of different factors such as the operating history of the facility – i.e. throughput, processes, chemical forms of uranium and earlier uranium handling techniques (see above) – as well as past malfunctions and accidents that had affected the facility interior through the release of UF₆ or UO₂, data on activity penetration depths into building structure surfaces and, finally, the applicable nuclide vector.

Using this information as a basis, it was then possible to proceed with the planning of the measuring and decontamination techniques as well as the allocation of residue and waste streams to disposal routes that were radiologically feasible and the most economical.

Suitable techniques were optimized and adapted, and new special applications were developed. For example, the in-situ gamma spectrometry technique that had been used for the first time in the uranium facility at Karlstein, is also being employed in Hanau for release measurements on building structures, containers with rubble and so-called "big bags" (Fig. 2), which consist of plastic sheeting with a capacity of one cubic meter and are used for the sampling and disposal of loose material (e.g. insulating material). Because of the low density of such material, the entire volume of several big bags can be scanned for contamination in just two measurement steps (one from the front and one from the rear). Each measurement takes 30 minutes.



Figure 2: In-situ release measurement of big bags

In-situ measurement will also bring improvements in terms of reliability and adherence to ambitious time schedules when cleaning building structures. Up to now it was common practice to decontaminate walls, ceilings and floors by removing a certain layer from the surface (between 3 and 5 mm thick, depending on the depth of activity penetration), in this way creating a new surface. As a second step for verifying that this new surface is free of contamination, further thin layers were again removed from specified surface areas. All material removed from these areas was collected, then homogenized, and samples were measured by gamma spectrometry. If the specified limit was exceeded, the second step had to be repeated.

The second step formerly needed for the release of such surfaces can now be entirely eliminated thanks to the in-situ measuring technique. This considerably speeds up the procedure of building release and reduces measurement costs. Further local decontamination is only necessary if residual activity is detected.

Another major advantage over traditional measurement techniques for release is that it is much more reliable as far as the adherence to release limits is concerned because it is possible – with just one measurement – to verify that a surface is free of contamination, not only within a layer of 3 to 5 mm but also to a depth of up to 50 mm.

DECOMMISSIONING OF MOX PROCESSING FACILITY IN HANAU

The MOX facility is presently in the cleanout phase; i.e. residual fabrication materials left over from the production campaigns are being processed into rods and assemblies suitable for long-term storage and shipment. This work is currently expected to be completed by early 2001. Of the material which was suitable for shipment from the start, 550 kg of plutonium in the form of PuO₂ powder and mixed oxides have so far been shipped to England and France. For further planning of the dismantling of this facility, it is especially important that the nuclear fuel still in storage as well as the transportable fuel material yet to be fabricated during cleanout can also be shipped off site in good time, namely by mid-2001 at the latest [1].

In March 2000 there will be a public hearing on the second stage in decommissioning the MOX facility: actual dismantling. The first partial license for this is expected to be granted in December 2000.

Detailed work procedures are currently being generated for the dismantling of the gloveboxes, the work areas and other equipment inside the fabrication building.

For the dismantling of a commercially operated plutonium-processing fuel fabrication plant, there is no directly applicable experience available from comparable decommissioning projects. However, extensive experience related to dismantling individual items of equipment or gloveboxes is available, gained from maintenance, repair and replacement work carried out over the period of more than 30 years during which the facility has been in operation. The equipment as well as the gloveboxes themselves can be reduced in size so that they can be conditioned using the existing waste treatment equipment and placed in 200-liter drums.

As an alternative to this proven approach, an innovative technique was also developed for conditioning entire gloveboxes, including their interior equipment, which comprises injecting a plastic foam which then solidifies into a hard foam inside the glovebox. A separate report was given at the Waste Management Conference in March 1999 on this in-situ foaming method [2].

However, each option and its variants have specific consequences as regards, for example, personnel exposure and risk of incorporation, waste volumes and licensing uncertainties. These all have to be carefully compared when selecting which option is to be used.

In the present case, a general comparison of the risks associated with the two approaches described above, in which all factors – and especially the impact on the time schedule and costs of the overall project – were taken into account, revealed that the already proven techniques offered clear advantages. However, for other facilities and different licensing conditions, the outcome could be a different one.

Before dismantling work is started on the gloveboxes, it is checked to what extent they have already been cleaned, or whether and where any residual fissile material may still be located inside the glovebox or its interior equipment. This information is important for ensuring that waste packages comply with the specified plutonium limits: a maximum of 50 g fissile material per 200-l drum, 50 g fissile material per 100-l glovebox volume (if the entire glovebox has been conditioned without prior dismantling) or 300 g plutonium in a 5.4-m³ container for final disposal.

The remaining hold-up inventory is determined using a measuring system specifically developed by BNFL for Siemens for this purpose: the Decommissioning In-Situ Plutonium Inven-

tory Monitor (DISPIM). A modular array of neutron counting assemblies is deployed around the glovebox. The signals from the detectors are evaluated in a transportable data processing unit. In combination with the results of a simultaneous isotopic composition determination, the system calculates the total quantity of plutonium inside the glovebox and also local hot spot masses and positions. The distribution of significant quantities of plutonium within the glovebox are presented as a 3-D graphical representation (Fig. 3).

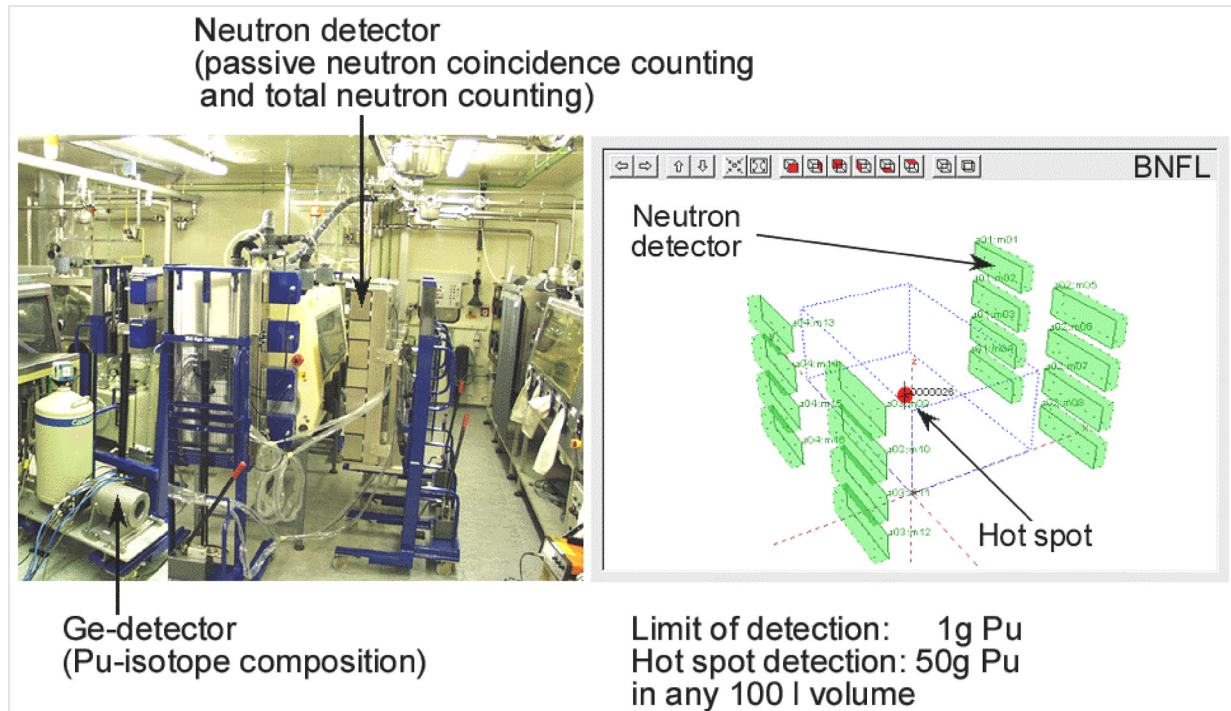


Figure 3: Pu hold-up measurement

DECOMMISSIONING OF HOT CELLS IN KARLSTEIN

In contrast to the three decommissioning projects described earlier, a broad nuclide spectrum and, in some cases, high activity levels along with the associated high dose rates therefore had to be accounted for in planning the decommissioning of these hot cells.

Operation of the facility was stopped in 1989 and decommissioning of the hot cells has been underway since that time. After the nuclear fuel from the last testing campaign had been returned to the owners (utilities), the cells still contained a wide variety of equipment and tools – from more than 20 years of operation – which required disposal as radioactive waste, with dose rates of up to 10 Sv/h and beyond.

Due to the high dose rates, all work in the actual cells was initially performed using remote-controlled manipulators. In individual cases, where no manipulators were available or where the capabilities of the manipulators were inadequate, specially developed robots were successfully deployed for the dismantling work.

Disassembly and decontamination work in the other rooms of the controlled access area required entry by personnel. Some of these rooms were highly contaminated. During the operating period of the hot cells, Am-241 had been released from liquid waste in the basement area, resulting in considerable airborne activity and also incorporation by personnel. Now, during dismantling of the contaminated equipment, activity including Am-241 was again released

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into the air. This required appropriate measures such as respirators and protective suits to minimize the risk of incorporation, and also posed a considerable challenge in terms of personnel training and radiation protection due to the need to constantly and closely monitor both radiation dose and incorporation.

Contamination hidden in wastewater drains, exhaust air ducts and in the building structures themselves represents a special problem. These require tailor-made decontamination and measuring techniques which, like the in-situ gamma radiation measurements already described above, are currently undergoing testing. Basement walls have in some areas been so deeply penetrated by contaminated liquid that their decontamination would result in structural problems along with the risk of activity being released from the building. Hence this work cannot be finished before the rest of the building is totally free of contamination.

Work is focused at the moment – and will probably remain so until mid-2002 – on decontaminating the cells and building including the pipe connections. Completion of the subsequent contamination measurements and release of the facility by the authorities is scheduled for 2003.

WASTE MANAGEMENT

In all nuclear facility decommissioning projects, disposal of the arising residues and waste is a major economic factor.

Statutory requirements to minimize radioactive waste volumes as well as the high costs of storage in final repositories – or, as in Germany, of interim storage until a suitable final repository becomes available – make it imperative for as much of the material as possible to be released from regulatory control.

The criterion applying for the release of materials from a nuclear facility is based on the so-called "10 μSv " concept. According to this concept, the consequences of any residual contamination must – for each path of further use – be so low that the total effective dose expected to be received by a single individual from the disposal or reuse of this material will be in the range of 10 μSv per year, a dose which can be considered negligible.

The radiological criteria governing clearance are expressed in terms of dose, which is impractical for making release decisions. Therefore these dose criteria are converted into mass-specific and surface-specific activity limits, below which release will lead to the above-mentioned negligible dose. The derivation of clearance levels requires a complex and thorough examination of the reasonably possible pathways by which humans can be exposed to released material. This model is already based on conservative assumptions. In addition to this, the authorities also imposed further, conservative restrictions which had correspondingly negative consequences with regard to the disposal of residues.

For example, the model analysis for disposal of material in landfills under restricted conditions assumes that only a maximum volume of 100 Mg/a with an activity level of 1 GBq/a may be disposed of in this manner each year. For the uranium facility in Karlstein, the authorities initially limited the maximum volume per year to just 50 Mg. However, as it could be demonstrated that the residual activity of the material intended for disposal in a landfill amounted to only a few percent of the clearance limit of 15 Bq/g determined for landfill disposal according to the 10 μSv concept (reduced by the authorities to 7.5 Bq/g for actual release), it was finally possible to succeed in having the disposable quantity raised to 150 Mg

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per year. As a result, all 300 tons of mineral residues that had arisen during decommissioning could thus be shipped off site.

Naturally, the actual volume of material (building rubble, soil, metal and burnable scrap, etc.) subject to prior authorization by competent authorities for disposal, recycling and reuse differs considerably for each individual decommissioning project, depending on the size of the facility and the ultimate goal of decommissioning. This becomes evident when one compares the waste balance of the uranium facility (67,900 Mg) with that of the MOX facility (5500 Mg) and with that of the hot cells in Karlstein (11,600 Mg).

The uranium facility is by far the largest in terms of volume. In addition, the decommissioning goal is to return it to green field status. In the case of the MOX facility, only the fabrication building will be demolished, whereas the plutonium storage bunker will be measured for contamination and released without being demolished. No contaminated soil is expected under the baseplate of the MOX building.

The proportion of radioactive material destined for disposal in a final repository is also different for the three projects mentioned above, i.e. 1.6% for the uranium facility, 12% for the MOX facility and 9% for the hot cells, based on the total waste balance of each facility. The relatively high proportion of material destined for final disposal in the case of the MOX facility results from the fact that decontamination or recycling of the fabrication equipment used in plutonium processing is neither sensible nor economically justifiable. The same applies for the highly contaminated equipment of the hot cells. In addition, the deep penetration of contaminated liquid into the building structure of the hot cells will yield more volume in the form of building rubble.

Since decommissioning of the uranium facility is producing considerable volumes of metallic residues, it provides a good example for showing how such materials can be treated and recycled in a cost-effective manner.

Steel recycling primarily depends on the decontaminability of the material in question. Small parts as well as parts of an unfavorable shape on which it is extremely difficult, or even impossible, to verify that they are free of contamination following decontamination are usually melted down. This method enables around 90% of the total volume of material to be released for unrestricted use. Around 10% leaves the furnace as contaminated material, above all slag, and then has to be disposed of as radioactive waste.

Other parts which have smooth surfaces can be decontaminated, either manually – by, for example, wiping them with water or decontaminating solutions – or by providing them with a new surface. For this purpose the metal parts are blasted over their entire surface in a suitable blasting unit and any paint, rust and other impurities are completely removed.

For the actual decontamination process – either manual or blasting – the parts do not require prior size reduction. The costs for dismantling and preparing these parts for decontamination are therefore slightly less than for preparing metallic parts for melting since the latter first have to be reduced in size to fit into drums for transportation and for feeding into the furnace.

The costs just for manually decontaminating smooth steel surfaces are slightly less than those for creating a new surface using blasting equipment – even if manual decontamination should require a second cleaning step – because the parts are easier to handle.

However, the advantage of surface blasting is that parts treated in this manner are much easier to release for unrestricted use. Whereas manually decontaminated parts have to be measured over their entire surfaces, blasted parts only have to be subjected to random sample measurements once metallically bright surfaces have been produced.

If one compares the specific costs determined for all treatment methods, then surface blasting of steel parts with steel shot is the most economical method for steel volumes of more than 200 Mg, even taking the capital and disposal costs of the blasting equipment itself into account (Fig. 4).

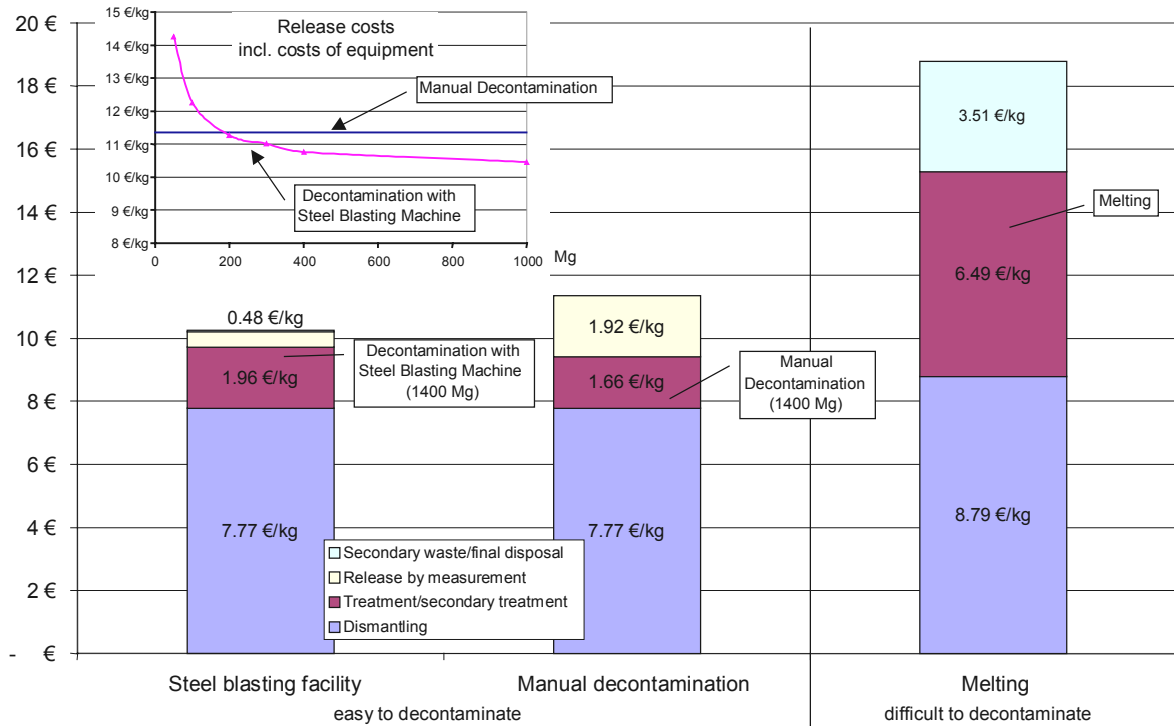


Figure 4: Waste treatment costs for metal scrap

For decommissioning of the uranium facility, around 1400 Mg will have been decontaminated by means of steel shot blasting.

APPLICATION OF KNOW-HOW AND EQUIPMENT FOR CONVERSION OF WEAPONS-GRADE PLUTONIUM

MOX technology together with irradiation of MOX fuel in a nuclear power plant can contribute to the worldwide disposal of ex-weapons plutonium by converting it into a "spent fuel standard" product.

Since 1992, both France and Germany have developed bilateral cooperation programs with Russia in order to assess the feasibility of irradiating ex-weapons plutonium in Russian reactors. The studies came to a similar conclusion: the loading of MOX fuel into Russian VVER 1000 and fast reactors, in particular the Balakovo units and the BN 600, is feasible.

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In the fall of 1996, Russia, Germany and France decided to combine their efforts in a joint initiative for the peaceful management of weapons plutonium in Russia. The cooperation was announced during the P8 expert conference in Paris from October 28 to 31, 1996.

Consequently, Cogema, Minatom and Siemens have launched a joint project which includes the design, construction and startup of a MOX fabrication plant in Russia: the DEMOX project. In November 1999 corresponding contracts were signed to start work on the basic design of the DEMOX plant.

What is the contribution of the Hanau facilities to this political effort for disarmament? As mentioned above, a new MOX fabrication facility was erected in Hanau next to the plant in operation. Its completion was stopped in 1996 after 95% of the equipment had already been installed.

The process equipment meets state-of-the-art requirements for safe and efficient processing of plutonium into MOX fuel. The production lines are largely automated and designed for a capacity of 5 Mg plutonium per year. The licenses for erection and operation had been granted prior to the stop.

The know-how from planning, installation and qualification of this equipment is still available, as well as the know-how from nearly 30 years of plutonium handling and MOX fuel fabrication at Hanau. In addition, Siemens is prepared to make either parts or all of the process equipment available at terms to be agreed upon in order to contribute to quick and cost-effective implementation of this international disarmament program.

CONCLUSION

Based on 10 years of practical experience from the cleanout, decontamination and dismantling of the nuclear facilities at Hanau and Karlstein, the following conclusions can be drawn:

- The cleanout process is not at all a routine procedure. An inventory of all fabrication residues should be carefully prepared and the feasibility of cleanout using existing equipment should be checked. After that, the cleanout operation should be performed within the limits of the existing operating licenses.
- A basic understanding with the responsible licensing authority regarding the decommissioning procedure and practical release limits for radioactive materials including the measurement procedure used by the operator as well as by the independent experts should be reached as soon as possible based on a carefully prepared document describing the entire project. After that, local administrative authorities have to be involved. It has proved useful to approach the nearby population and even local opponents in order to improve acceptance for the project as well as for the later withdrawal of nuclear material or waste of any kind from the site. A clear vision of how the site could subsequently be used is also very helpful.
- Last but certainly not least, the availability of experienced employees in key positions with detailed knowledge of the facility and the former operating procedures is a mandatory prerequisite for the planning phase as well for limiting expenditures and also for remaining within given time schedules during the decontamination and dismantling steps.

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