PROCEDURES, TECHNIQUES AND RESULTS OF DECOMMISSIONING WÜRGASSEN NPP

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Abstract

Würgassen NPP was finally shut down in 1994 and decommissioning of the plant commenced in April 1997. The reasons for the decision to decommission and the consequential planning, the strategy of the operator in obtaining approval and authoritative procedure, the approach and results of the radiological characterizations and their effects on decommissioning will be presented in this address. The employed techniques for dismantling, cutting, decontamination, the equipment and the importance of infrastructure including personnel issues will be described. The main disposal objectives, the relative requirements and verification procedures, the resulting economic considerations and the correlative mass flow rates will be given. The objective of this address is the presentation of extensive radiologically justified, economically orientated and industrially managed, complete dismantling with high throughputs, which will set a first standard in Germany for comparable projects.

1 Introduction

Würgassen NPP is a single-unit boiling water reactor plant with a capacity of 670 MWel. It was commissioned by PreussenElektra and constructed by AEG / KWU between 1968 and 1971 [1].

PreussenElektra decided to decommission the plant in May 1995. The decision to decommission was at the same time a resolution to completely dismantle the plant to a “green field site”.The main arguments for immediate decommissioning of the plant were at the time [2]:

- further employment of a part of the personnel,
- availability of a final storage site for radioactive waste at Morsleben (ERAM),
- the political and moral obligation not to leave any industrial ruins to the next generation, and
- to be able to opt for safe encapsulation at any time.

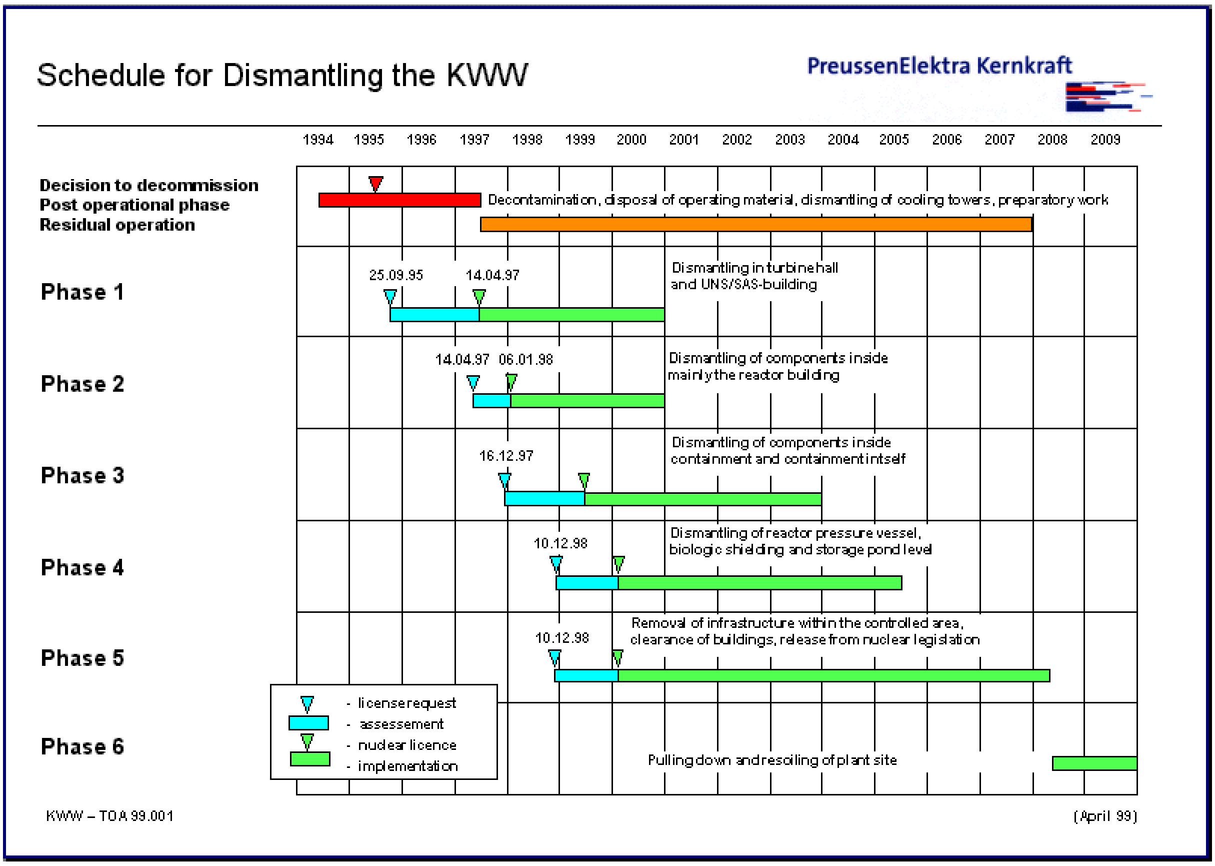
The period of decommissioning was estimated to be 10 to 12 years. This period has been divided into 6 different phases (fig. 1).The definition of the phases resulted from considerations concerning logistics and distribution of activity in the plant.Initially, the dismantling of the equipment in the turbine building was defined as Phase 1 and application was made for this. This included the dismantling of turbine, condenser, condensate system, preheaters, feed-water, off-gas system and the respective auxiliary systems. Phase 1 also included the dismantling of the emergency system (UNS) which is an external impact secure emergency and residual heat removal system. Phase 2 relates to the systems with higher contamination levels in the reactor building and correspondingly higher dose rates outside the containment. These mainly concern the high and low pressure emergency cooling systems, low pressure residual heat removal systems, main steam, reactor water clean-up, and the respective auxiliary systems. Phase 3 includes the systems inside the containment. Additionally, Phase 3 includes the dismantling of installations in the reactor pressure vessel and the storage pool. Phase 4 relates to the dismantling of the reactor pressure vessel and the biological shield. In Phase 5 the infrastructure within the Radiation Controlled Area (RCA) will be removed. The contamination levels in the buildings will be shown not to exceed the stipulated limits and the plant will be released from the Atomic Law. In Phase 6, the demolition of the nuclear power plant will be carried out under non-nuclear conditions and the area will be recultivated.

The prime objectives of the entire project are:

- general and radiological maintenance of industrial health and safety standards,
- optimization of economic viability,
- a high, continuous mass flow of disposal.,
- a high part of unconditional clearance

The dismantling of the Würgassen NPP has prototype characteristics for industrial dismantling of nuclear power plants.

Fig 1. Schedule for Dismantling the KWW



2 Procedure

Prerequisites for Authorization

The so-called work documentation procedure for the management of dismantling in accordance with approval is laid down in the basic authorization of April 1997 [3]. The work documentation describes exactly the location, scope, types of material, masses, dismantling, cutting and decontamination processes. It also covers the radiation protection measures to be applied and disposal objectives for the entire works involved in decommissioning. It is drawn up by the operator, submitted to an independent expert appointed by the authority, and if it agrees the authority will approve. This method of documentation is the basis for the implementation of decommissioning.
The work documentation is fundamentally based on a result report which characterizes the entire task of dismantling involved in advance and is radiologically as complete and detailed as possible. For this purpose the complete dismantling work, i.e. systems, structural elements, cables and components, is extensively examined by using material, scrape and wipe tests. The spatial distribution of dose rates are determined and possible new decontamination processes are tested.
So far, approx. 12 000 samples have been taken, evaluated, and the results have been documented in 100 reports comprising on average of 50 - 60 pages. Quintessence of the result report are radiological conditions for dismantling, decontamination and disposal which are then included in the work documentation.
The most important outcome of the result report is the nuclide vector which is assigned to a system, a spatial area or parts of it. The nuclide vector results from sample material in a system and the nuclide distributions in the individual samples. On the basis of these experimentally and statistically determined distributions, a nuclide vector is defined by applying conservative principles and should meet the following requirements:

1. maximization of the summation formular for specific activity for cleareance in accordance with table 1[6],
2. maximization of the summation formular for the surface activity in accordance with table 2 [6],
3. maximization of those nuclides which can not be registered by the total gamma decisive measurement,
4. the optimization of the three single maximizations is performed without any preferences.

The nuclide vector is the determining factor for radiological health and safety protection at work and cleareancel. It is the most important characteristic for controlling material flow. To date 50 nuclide vectors have been defined. Three very different examples for an average nuclide distribution is presented here (fig. 2).

Fig 2. Three examples for nuclide-distributions

system	[%]										
	C14	Fe55	Co60	Ni63	Zn65	Sr90+	Ru106	Sb125	Cs137	α	Pu241
off-gas	-	-	1,7	0,1	-	2,5	-	0,5	90,5	0,5	4,2
MP-Turbine	0,1	0,3	40,2	1,6	2,8	0,8	3,7	1,5	23,1	3,0	22,9
standard	0,2	0,5	62,8	2,4	-	0,9	-	-	33,2	-	-

After the maximization which is mentioned above is performed the defined nuclide vectors changes as presented in (fig. 3).

Fig 3. The three examples for nuclide-distributions after maximization

system	[%]				
	Co60	Sb125	Cs137	α	Pu241
off-gas	-	7,5	92,5	-	-
MP-Turbine.	28,7	-	-	6,9	64,4
standard	52,4	-	47,6	-	-

The first example stands out because of its high proportion of cesium 137 and strontium 90+. This is typical of off-gas system pipes directly connected to the turbine condenser. These removed the non-condensable gases from the turbine condenser. The Strontium 90+ portion is dominant close to the condenser and less dominant at the end of the off-gas system in the charcoal filters.
The distribution of a vapor carriing system with a significant α- portion is shown at the middle-pressure turbine.
The last example was initially determined by the analysis of evaporator bottoms as a standard nuclide vector. It can be applied on systems connected to the pressure vessel with high contamination levels that are not subjected to system decontamination.
A characteristic feature and a significant advantage of this procedure is that all conditions under which dismantling has to be carried out are agreed between the operator, authority, expert and contractor before work begins. This is the only way to guarantee rapid dismantling and trouble-free material flow up to the stage of clearance or landfill.

Technique

Dismantling techniques

For separative work carried out in the areas of the turbine building and reactor building, i.e. at a dose rate of some µSv/h in most of the areas up to about 1mSv/h in the maximum, the well-proven techniques as shown in fig. 4 are applied. The following criteria were decisive in selecting these techniques:

- compatibility with radiological requirements
- high cutting velocity
- flexibility
- simple operation
- produces little dust and dirt

The outside contractors that are engaged to carry out the work of dismantling receive a standardised cutting plan from the operator. This plan stipulates how the individual pipes and fittings have to be cut depending on the nominal diameter. The disassembled components will then generally be loaded into skeleton containers. Large components such as big heat exchangers or pipes with a nominal diameter of more than 800 mm are an exception. These are cut to a size which allows them to be transported from the dismantling site.
Components pre-cut by the contractor are taken to central post-dismantling sites. Post-cutting is carried out in detached ventilated tented bays or containers. The air in these work stations is extracted by means of mobile

filtering installations which attain 100 per cent filtration. The material is then cut to such an extent that it can be subsequently conveyed to the decontamination stations.

Fig 4. Tools used as Würgassen NPP

tool	quantity
plasma cutter	5
oxyacetylene cutter	3
electrical saw	30
low clearance split frames	5
portable grinder	100
hydraulic shears	3
nibbler	5
2000 supercompactor	1
double metre belt saw	1
decontamination chamber	5

Decontamination

The following techniques are predominantly used for decontamination:

- in-situ system decontamination
- manual steel grit blasting

An in-situ system decontamination was carried out on higher-level contaminated primary water or steam carrying systems before dismantling began [4]. The results achieved are summarized in fig. 4. The Siemens HP/CORD D UV and CORD CS UV processes were used to remove all oxyde structures from the surfaces. On average, residual contamination levels of 10 - 200 Bq/cm2 were achieved. An unexpected and undesired effect of this system decontamination was that, in comparison to the non-contaminated condition, the proportion of alpha emitters in the nuclide composition of the decontaminated areas was relatively increased.

By using steel grit blasting, the surface is mechanically removed up to a depth of 70 µm per blasting action. The blasting agent is accelerated by means of compressed air and emerges from a manually controlled jet. The spent blasting agent is removed from the blasting chamber and processed via a filtering installation. Here, the contaminated surface particles that have been removed and grid dust are separated from the blasting agent. The blasting agent is then fed again into the jet. This method prevents contamination of the blasting agent and thereby preventing re-contamination of the component. For every ton of blasted material 5 kg spent blasting agent and dust is created.

Fig 5. Results of in-situ-decontamination

system	reduction of doserate (DRF) DF
reactor coolant clean-up	7
residual heat removal	9
recirculation loop	35
emergency cooling	108
off-gas	373
fuel pool cooling	64
main stream	10

Infrastructure

Decommissioning is mainly a logistic exercise. A long-term concept for transport, processing and storage of materials has to be worked out before decommissioning work begins. This concept determines the sequence of dismantling.

The boiling water reactor with its relatively large RCA and extensive turbine hall provides a space for all treatment equipment and the appropriate storage area. In order to achieve a certain standardization for the major part of material flow, Würgassen NPP uses skeleton containers of the size 120 x 100 x 60 cm for the transport of material. This means of transport has become a well-proven primary quantity for the entire logistics.

Industrial dismantlement of a nuclear plant creates completely new demands on the personnel who had operated the plant up to decommissioning. Therefore, the personnel structure has to be adjusted and the personnel have to adjust to the new task arrangement. Experienced personnel is absolutely essential for the residual operation and radiology in the plant.
At present 12 nuclear plants are being dismantled in Germany [5] which means that "decommissioning" is also a significant market with a prolonged perspective within the nuclear supply industry. Hence, for reasons of economy and personnel management it therefore makes sense for the operator to carry out decommissioning with a mixture of one's own employees and external personnel. Würgassen NPPs employees undertake all the direct responsibilities of the licence holder, run the residual operation and carry out the overall economic planning, the following up of orders and the supervision of dismantling. The plants own personnel fulfill in particular, the main management tasks of radiation protection and disposal. The amount of strain placed on personnel in these fields during decomissioning far exceeds that experienced during normal times of operation. The division of the operator's own personnel and those of outside contractors and the individual areas of work are shown in fig. 6.

Fig 6. Configuration of personnel

job	operator	contractors
decommissioning - planning	15	12
decommissioning - execute	4	33
maintenance / workshop	20	34
infrastructure	30	57
house keeping	1	44
radiation protection - waste managment	30	63
operation - shift	24	
administration	20	5
guard		26
total	144	274

3 Disposal

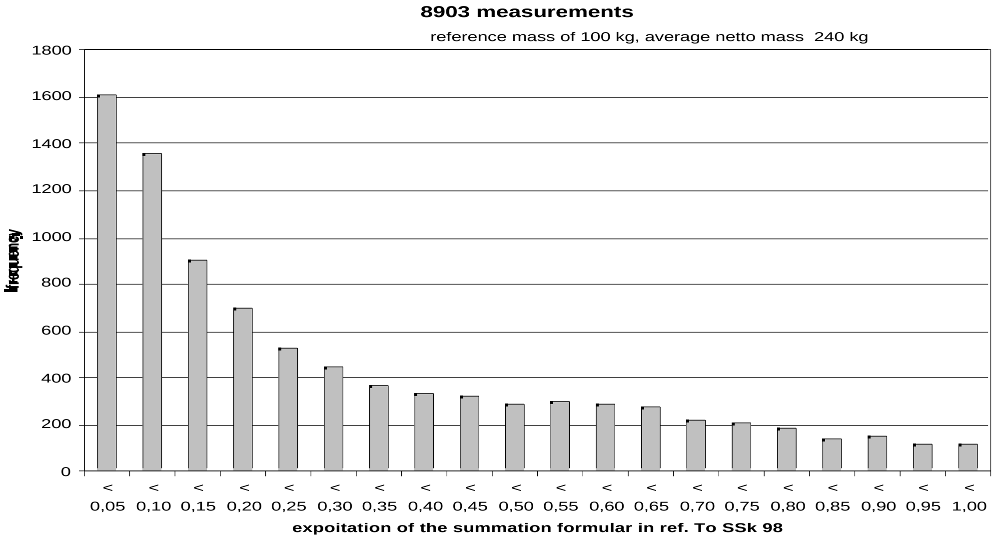
Disposal objectives

The competent authority approves objective and conditions of disposal options, establishes additional requirements and fringe conditions in the authorization.
The following disposal options have been employed to a significant degree during Phases 1 and 2.

Unrestricted clearance

Unrestricted clearance is possible by covering nuclide vectors for all solid bodies which have defined surfaces and that are accessible and measurable. In order to prove a contamination less than 0,5 Bq/cm_ β, γ and 0,05 Bq/cm_ α, a preliminary measurement of the total surface is carried out in the RCA. A decisive measurement is carried out after outward transfer at a special gateway from the RCA which determines the total γ activity of the material in a lead shielded bulk chamber with 24 plastic detectors by applying a conservative reference mass of 100 kg (as a rule net masses are approx. 250 kg). As a result of this the mass specific activity has not to exeed the mass specific clearance level in table 1 [6]. By a summation formular the sum of the coefficient of the specific activity for clearance and the relativ cleareance level of individual radionuclides of the actual defined nuclide vector has to be calculated. Radionuclides for which as a whole the partial sum of the coefficient does not exceed 10% of the total sum of the coefficients maybe disregarded.
A summary of the results of the total γ decisive measurement is presented in fig. 7. This measurement device has proved to be a very reliable and sensitive measuring system. It can also detect low activities on unfavourable geometrical structures.

Fig 7. Distribution of mass-specific activity in unrestricted clearanced material as detectted by the total γ –measurement device.



Controlled Melting Down

Controlled melting down is mainly used as decontamination by remelting. The resulting product has to have a mass specific activity of less than 0,8 Bq/g related to Co60 e.g.- if need be, after a certain decay storage period. Clearance of such product has to obeye the requirements of the 10 µSv-concept. Metallic components that have a low level of contamination and where it is difficult and costly for geometrical reasons to prove if the surface area limits are met, are sent to controlled melting down.
In contrast to unrestricted clearance, "best-estimate" methods are applied to determine activity for controlled melting down.

Landfill and Thermal Treatment

Weak contaminated materials with a low commercial value such as insulation materials, cable insulation and building rubble can be disposed of at available local waste tips. These means can be utilized if the mass specific activities are below the standard values recommended by the German Commission on Radiological Protection (SSK) in [6]. Liquids as oil can be treated together with other inactive waste in a thermal treatment plant. These values ensure that the EU-wide accepted 10 µSv-concept is observed.

Radioactive waste

Radioactive wastes includes all residual materials which cannot be disposed of by any other means for technical or commercial reasons. Apart from the usual operational wastes, dismantling particularly creates components as radioactive waste where decontamination is not justified for either reasons of dose or cost.
On the one hand, waste avoidance has been intensified and disposal options such as controlled melting down, incineration and dumping at waste tips have been increasingly utilized since the closing of the final storage ERAM. On the other hand, radioactive waste will now be wholly supercompacted and stored at an intermediate storage at the plant site.

Mass flow rates

Since the beginning of decommissioning, approx. 5 000 tons of predominantly metallic components have been dismantled and disposed of from the RCA in fig. 8. This represents a throughput of about 9 tons per working day. The quotas given in fig. 9 are apportioned to the main disposal objectives mentioned above.

Fig 8. Distribution of accumulated masses

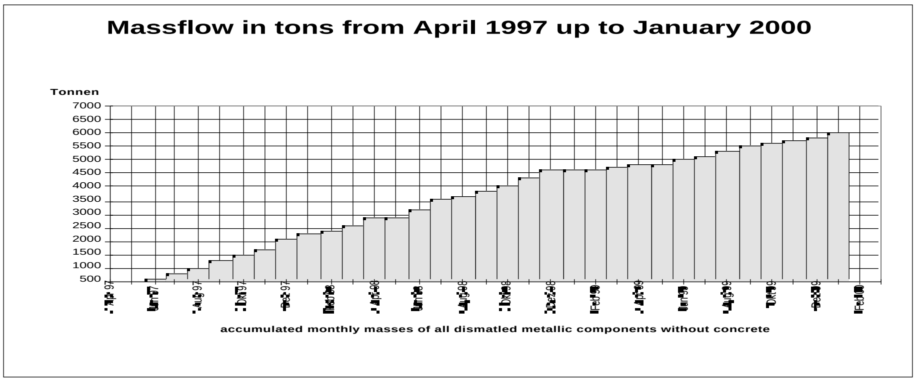
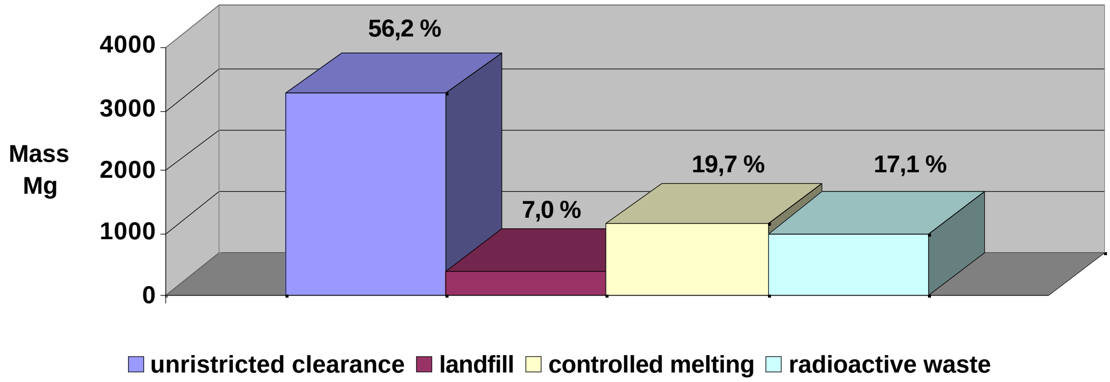


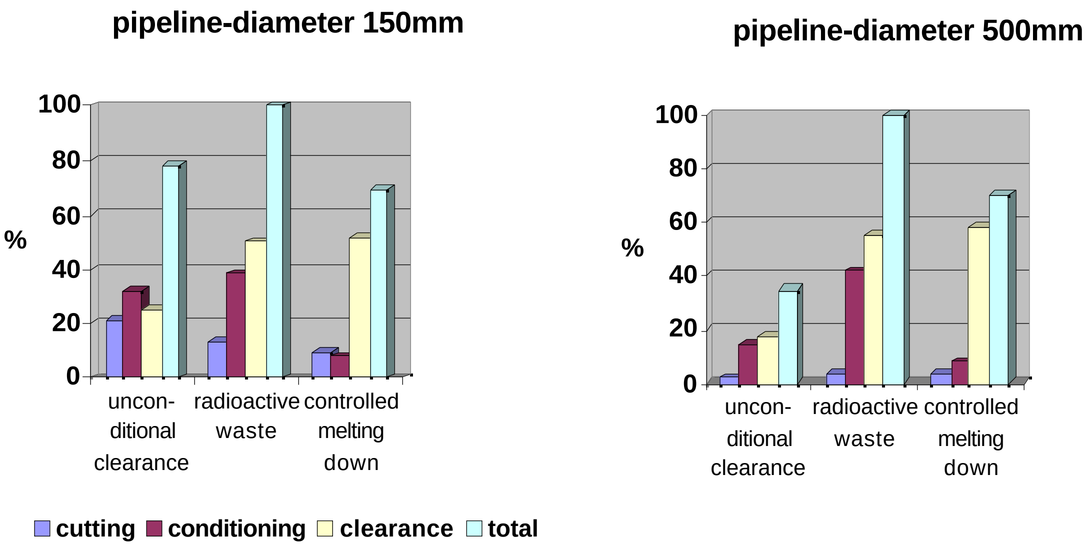
Fig 9. Distribution of masses on different disposal pathes (Jan. 1997 - Apr. 1998)



4 Economy

The disposal objectives of the dismantled material are determined by radiological as well as economical aspects. For metallic components of different sizes all costs form dismantling to disposal were considered. Fig 10 shows that controlled melting down is advantageous compared to unrestricted clearance for diameters < 150 mm.

Fig 10. Example for cost and relation of different disposal objectives



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