Optimisation of Dose Exposure at Cask Handling for Intermediate Storage

Konrad Dreesen, Dietrich Hoffmann, Bernd Lorenz
GNS Gesellschaft für Nuklear-Service, Germany

Spent Fuel Management in Germany

In Germany spent fuel will exclusively be disposed of in deep geological formations. It is interesting to note that the original German Atomic Act required the spent fuel to be reprocessed. After the attempt failed to build a large reprocessing plant in Germany, the reprocessing has been done in France and the UK. In 1994, the Atomic Act was modified to provide an option of permanent storage in addition to reprocessing. In 2000, the Federal Government decided to phase out nuclear power by limiting the existing plant quantity of electricity being produced. This would phase out nuclear power around 2022. In addition reprocessing had to be discontinued in 2005 and shipments to reprocessing plants have been stopped after June 30th, 2005.

Until the availability of a final repository spent fuel assemblies are stored in casks in intermediate storage facilities. The original intent was to store any spent fuel and radioactive waste in an underground salt dome at Gorleben. Investigations were stopped for a 10-year moratorium. A deep geological repository should be available until 2030. The selection procedure of a suitable repository site is continuing, with the possible use of the repository site at Gorleben. In the meantime, dry storage facilities have been built and commissioned at all German nuclear plant sites, in addition to the existing two central storage facilities at Ahaus and Gorleben. An exception is the NPP Stade, shut down in 2003, that shipped its fuel for reprocessing before the deadline. Figure 1 shows the map of intermediate storage facilities in Germany. At present 16 storage facilities are in operation containing 793 loaded casks. Another dry storage facility is planned at the site of the NPP Obrigheim, shut down in 2005, replacing the existing wet storage facility.

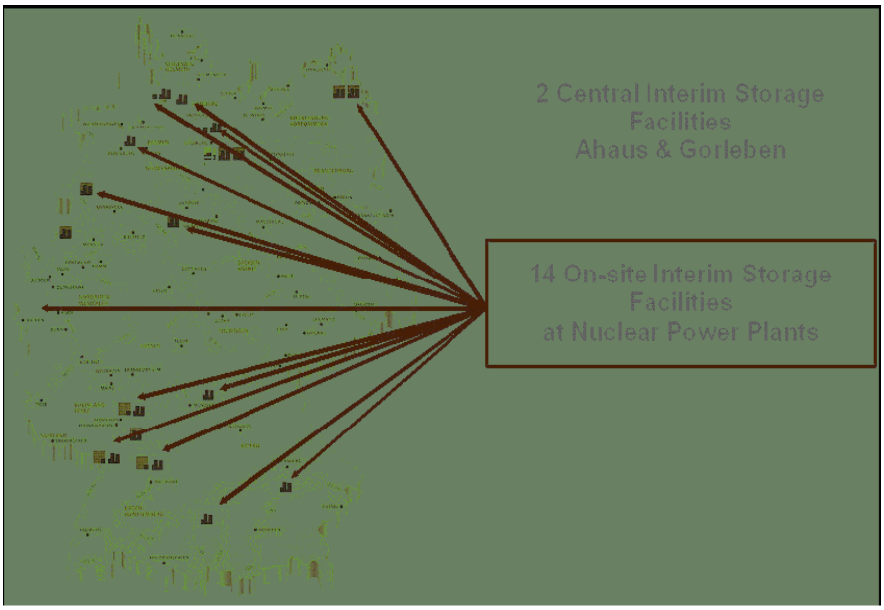


Figure 1:
Spent fuel storage facilities in Germany

Cask of the CASTOR®-Type

The casks used in Germany for spent fuel management are mainly of the CASTOR®-type. They are manufactured by GNS Gesellschaft für Nuklear Service mbH, which is the competence centre for the German utilities in the field of spent fuel and nuclear waste management from German NPP. For the PWR and BWR spent fuel assemblies of light water reactors casks of the CASTOR® V/19 and CASTOR® V/52 type are used which constitute dual purpose casks for transport as well as for storage.

The casks of the CASTOR®-type consist of a cask body with four trunnions for handling and two lids closing the cask. Inside the cask body a basket is placed taking up the spent fuel assemblies. The lids are sealed off the cask body with metallic gaskets of the Helicoflex-type. The cask body is cast-iron and is manufactured of one piece as a whole.

These metallic casks are resistant against accidents. They are licensed for storage as well as transportation on public roads. Casks guarantee the safe enclosure of radioactivity. Practically the double lid system with an intrinsic gas pressurized barrier provides zero release of radioactive material. The huge wall thickness provides the necessary shielding. Heat removal up to 40 kW thermal power and criticality safety of spent fuel are further safety features of the casks. These above mentioned safety requirements of the casks are ensured during normal operation and in case of severe accidents including an aircraft crash.

The casks are stored in storage buildings with passive cooling by natural convection. The buildings provide weather protection and additional shielding. Casks in combination with a building reduce the dose exposure to public far below regulatory requirements.

Cask Loading

The cask loading is carried out inside the reactor building on reactor floor level during normal operation of the reactor. The loading and preparation for storage of a cask takes between 5 and 12 days around the clock. The essential process steps are the following:

- Positioning of cask into the pond
- Loading of fuel assemblies into the cask
- Mounting of primary lid onto the cask
- Cask removal from the pond
- Decontamination of primary lid surface
- Contamination & leak testing of the primary lid
- Dewatering and drying of cask internal space
- Lid mounting and leak testing of secondary lid
- Cask locking out of reactor floor

Both staff of NPP and of GNS is involved in the procedure of cask handling. The essential working steps on the cask are carried out by GNS-staff. A normal loading team consists of 12 persons. Two of them are permanently present in the controlled area. The decontamination work and the operational supervision of radiation protection are done by NPP-staff. The whole procedure is monitored by consulted experts of the competent atomic supervisory authority. The dose uptake of the staff averages between 4 and 5 man mSv per individual loading of a CASTOR®-V-type cask. This is divided into the mentioned staff groups as follows:

	Dose	Time	Dose/Hour µSv/h
Cask Performance	68 %	52 %	4,31
Decontamination	14 %	16 %	3,01
Radiation Protection	11 %	24 %	1,64
Experts	7 %	8 %	2,92
Total	**4.000 man µSv**	**1.188 h**	**3,37**

Optimisation Measures for Dose Reduction

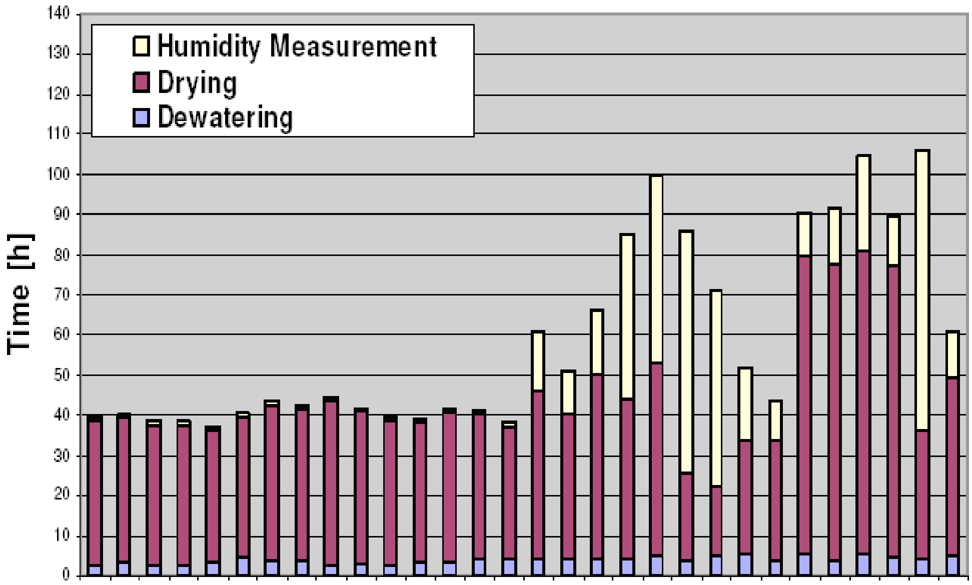
GNS has four teams for cask handling. These teams can load casks in four different NPP simultaneously. Each team has their own identical equipment. At present about 50 casks are loaded per year only. The capacity of the handling teams is sufficient for 80 cask loadings per year. That could be necessary in the case of simultaneous final shut down of several NPP. The time between cask loadings is needed for maintenance of equipment as well as for instruction and training of personnel.

It is proven practise to use experienced service teams in fixed formations because everybody knows his task and is used to one another. The continued instruction and training of personnel are carried out on the test and training rig of GNS at the cask manufacturing site, where the NPP-staff is trained as well. The most frequent failure sources are the different conditions at the NPP and the daily routine of handling sequences.

The cask service is done on the basis of a detailed handling sequence plan. Prior to beginning the plan is checked by the experts and approved by the authority. Each essential working and checking step is signed on the sequence plan by the operator and the expert. Afterwards each individual cask loading is evaluated. Twice a year the experiences are exchanged among the teams as well as the NPP. Thus the cask service will be improved consistently.

Technical Measures for Dose Reduction

From the beginning of cask service the analysis of dose exposure was emphasised. Radiation protection by additional shielding as well as prevention of contamination instead of decontamination by consequent using of a plastic contamination protection shirt for the cask are general examples of technical measures for dose reduction. The analysis has been focussed on time consuming steps and steps in high radiation fields. The analysis shows the highest dose rates occurring during dewatering, drying and measurements of residual humidity of the internal cask space. The casks are loaded in reactor ponds under water. After dewatering and drying of the internal cask space the residual humidity has to be measured due to check the cask dryness. Initially a measuring device using the dew point mirror method was used for this purpose. The mirror was frequently polluted and needed to be recalibrated. This led to widely varying measuring times and the work could not be reliably planned. The time period needed for the above mentioned three steps ranges from 45 to 107 hours for cask loading in 2007. Due to the change to the pressure-rise method in the frame of the humidity measurements, the time needed is now equal for all casks and considerably lower than using the dew point mirror method. At present 45 hours are needed. Thereby the dose uptake of the cask handling staff could be reduced to 2.5 man mSv on average. Figure 2 illustrates the shortening of time schedule by the new humidity measuring method.



Loaded Casks
Figure 2: Comparison of cask handling time

A further optimisation was the use of remotely controlled valves which are used for cask service at the top of the cask where the highest dose rates occur. To switch the valves no staff is needed in this area. Preparations have been made for automatic data acquisition. The measured values will be recorded automatically by computer. The time consuming drying process could be supervised from outside the controlled area where the dose rate is much lower. For this reason the presence of staff in the controlled area is limited to a minimum.

Conclusions

Necessary work in radiation fields requires thorough planning and good skills of service staff. Focussing time consuming process steps, repeated procedures and steps in high radiation areas are appropriate approaches to a careful analysis of dose exposure. Considerable dose reduction at cask handling was achieved by using a new humidity measuring method and remotely controlled valves. The handling of casks for intermediate storage is a good example for dose exposure optimisation by use of technical measures instead of human beings.