Handling of HLW Flasks in German NPP-Safety Aspects

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Abstract

The purpose of this paper is to present an actual description of the important regulations and procedures and their related equipment ("load chains" consisting of cranes, load-bearing equipment and load-attaching points) needed for handling of HLW flasks. It shows especially the great number of safety measures on design and operation prepared in German NPP. Our independent expert approval, testing und checking of all necessary safety measures is ordered by the responsible supervision authority (e.g. Land authority: Bavarian ministry for environment and health (StMUG).

The range of the equipment covers the reactor building crane, auxillary hoist of refuelling machine, gantry crane, diverse lifting beam equipment, diverse waste management equipment(e.g.carving, drying), diverse types of waste flasks, flask trunnions and special handling tools like grippers. The flasks are loaded with high level radioactive materials like control elements, fuel channels, structure elements. The handling equipment is subjected to a general safety analysis taking into account the ageing of the equipment and the progress of standards. Compliance with the current valid requirements of the state of science and technology as required by German Atomic Act and particularly of the nuclear safety KTA-standards (3604, 3902, 3903 and 3905) has to be examined.

Burnt fuel elements (BFE) are here not regarded as HLW, but in case of the handling and disposal of the BFE the following descriptions generally are analogues valid as well (beside that KTA 3602 is used for BFE).

The higher protection targets for "safe handling and transportation of heavy loads and safe handling of radioactive materials and waste" are to avoid a criticality accident, the release of radioactivity and inadmissible effects on safety related technical equipment and buildings.

The scope of the safety related steps are to check whether these protection targets are fulfilled for all important technical handling and transportation processes. In particularly the design and manufacturing of the equipment and the handling instructions are examined.

Introduction

Handling and transport of Flasks for High Level radioactive waste (HLW) are necessary and important for the operation of a nuclear power plant (NPP). Disposal of HLW must get a formal agreement or approval by the local authorities and must therefore fulfil all relevant safety requirements. To get this approval for the handling and transport in Germany an expert opinion with a positive result of evaluation of the handling and transport procedures and equipment is necessary: Each step must be analyzed for evaluation. TÜV Süddeutschland has performed a lot of such safety evaluations in order of the competent local authorities. For handling inside the NPP-area the atom act and the traffic act come together.

Outside of the plant the national regulations of the traffic act (e. g. GGVSE, TRV) and the international guidelines (IAEA safety regulations TS-R1 ADR, RID) are in foreground oft the safety assessment. This national and international regulations must be observed for the appoval of the flask for High Level waste (HLW). Figure 1 shows a simplified description of the correlations between the different authorities and groups.

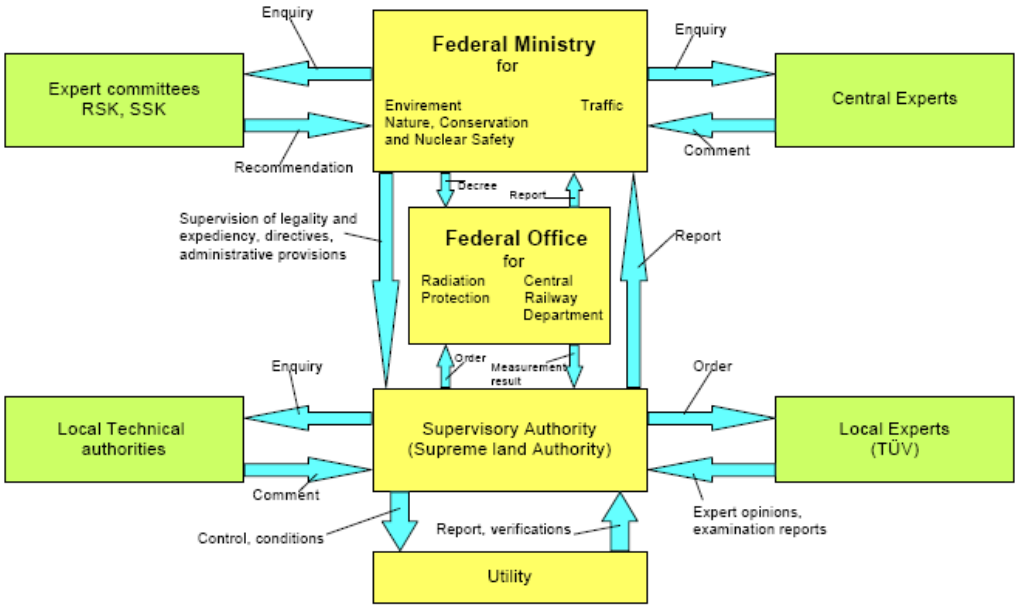

FIG. 1. Approval Structure for Nuclear Transports

Handling Steps

To handle a heavy flask (up to 100 to) in the plant all safety important steps, must be fixed in the sequence step plan. These steps can roughly be subdivided in:

- **Lift of the empty flask**

After arriving the empty flask (e.g. GNS flasks M 80 T or M II/15) is lifted from a lorry or a railway wagon with the gantry crane and the horizontal lifting beam to the height of the rails leading into the material lock of a pressure water reactor (PWR) (see Figure 2) or up to the height of the reactor floor of a boiling water reactor (BWR) (see Figure 3).

- **Horizontal Transport**

The flask is set down on the transfer carriage and is driven on it into the material lock. After closing the outer door and opening the inner door of the lock the horizontal transport into the containment on the so called reactor floor can be performed (only in PWR).

- **Vertical transport into the storage pool**

From its horizontal position on the transfer carriage the flask is turned into a vertical position by the reactor building crane, lifted up from the transfer carriage and set down on the service-place on the reactor floor. After removing the lid the flask it is prepared for the next handling steps contamination-checks etc. Then the flask is lifted, transported to the pool and lowered down to the ground of the pool.

- **Loading the flask with HLW**

In the station under water – special place in the storage pool -the flask will be loaded with the HLW material (e.g. irradiated fuel channel, cutted core components as neutron flux measure lances, neutron sources, steering elements). By means of special lifting equipment and the hoist of the reactor building crane or the auxiliary hoist refuelling machine in accordance with a specific loading plan.

Way back

After loading the lid of the flask is set down under water and the flask is removed by the reactor building crane onto the reactor floor. The flask is got ready (fixing the lid, drying, leak tightness test). The remaining steps are performed as the steps 1 -3 only in the reverse order -with additional quality assurance -and measurement steps.

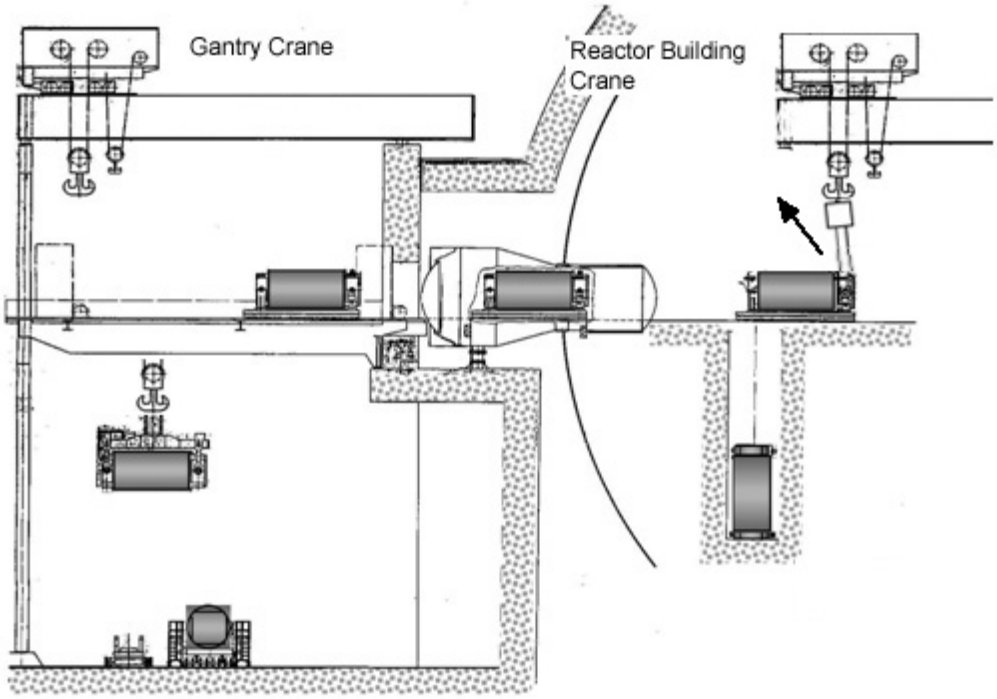

FIG. 2. Flask Positions in a PWR**.**

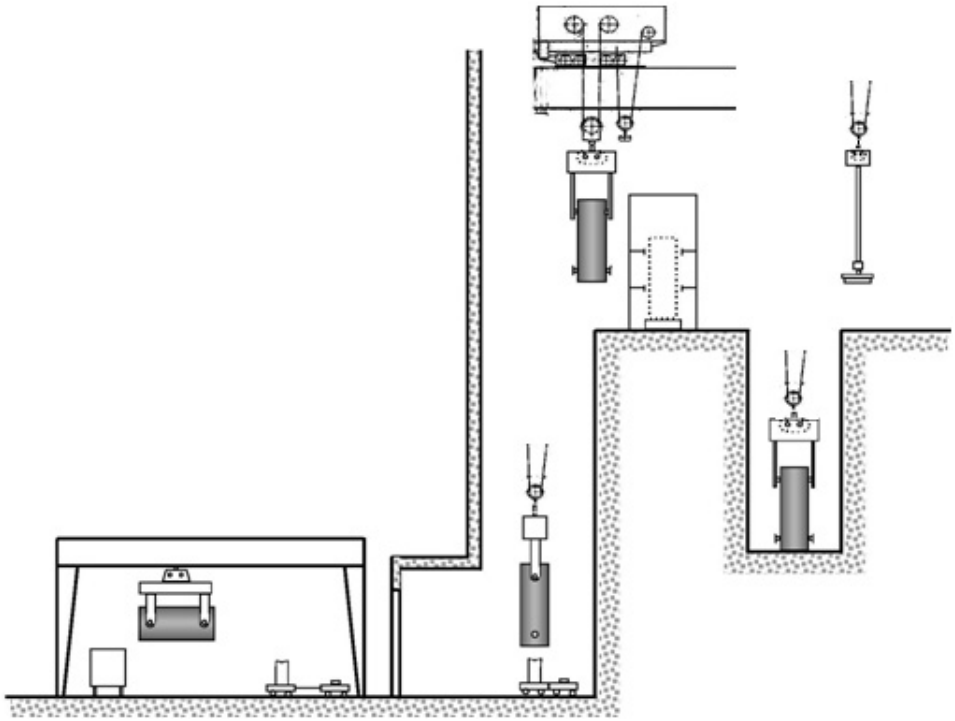

FIG. 3. Flask Positions in a BWR.

Safety requirements and evaluation standards

The safety standard of German NPP as the technical basis of the different necessary approvals is defined by a hierarchy of technical requirements as are presented in Figure 4.

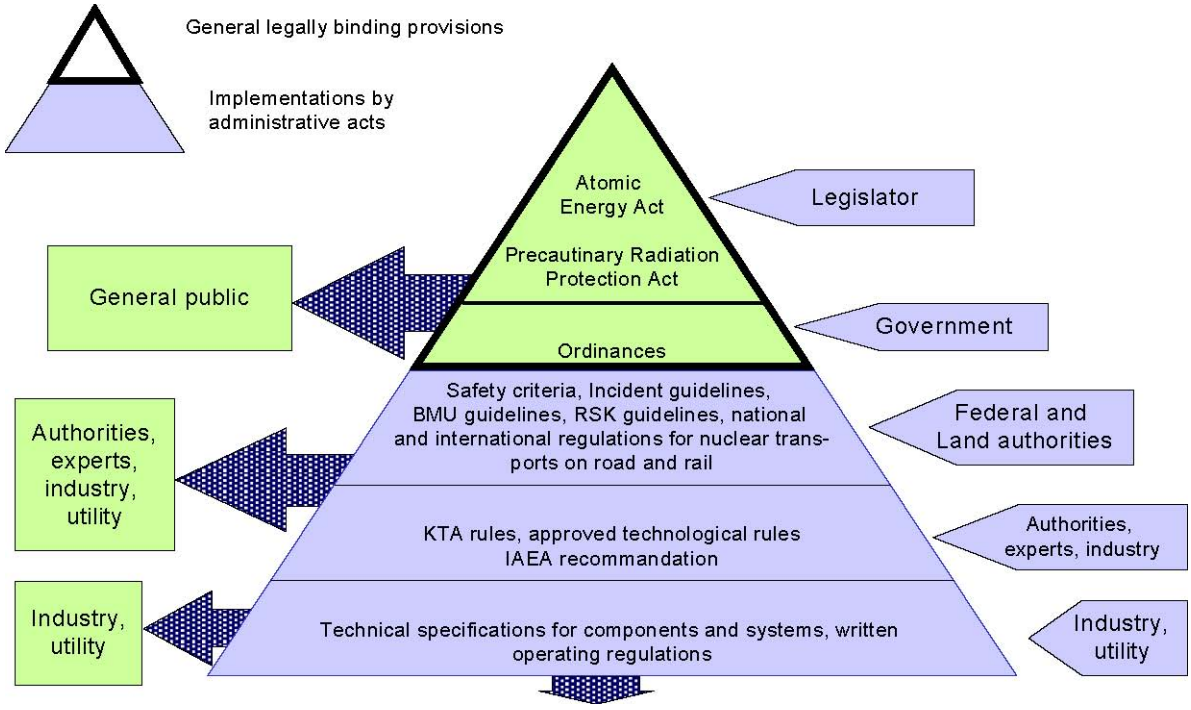

FIG. 4 Hierarchy of legal nuclear provisions.

For all design and accident conditions it must be assured that the four higher safety goals shall be fulfilled:

- reactivity control, subcriticality (1)
- residual heat removal (2)
- enclosure of radioactive substances (3)
- limitation of radioactive exposition (4)

For handling and transport of HLW flasks the requirements (1), (3) and (4) shall be fulfilled by the design of the flask. The positive result of the design approval can be seen from the so called Typ B (U) certification of the flask (published by the Federal authority BfS).

All handling and transport steps with a flask in a NPP are to be performed in the way that no risk is induced for the plant, for the staff and for the environment. For all the handling and transport steps and for all the equipment the fulfilment of the state of the art concerned to the atomic act is necessary. At all situations keeping the higher safety goals must be guaranteed at anytime: The state of the art is fixed generally and in detaild by:

- relevant acts
- ordinances
- safety criteria and guide lines
- national and international transport guidelines
- KTA-rules (3604, 3902, 3903 and 3905)

- **Fulfilling of the safety requirements**

- **Lifting of empty flasks and lowering of loaded flasks**

Type B (U) -Flasks are designed by calculation and tested for a fall from a height of 9 m onto a rigid fundament. Additional results of analyses of calculations or experiments must show that a fall from greater heights onto a realistic fundament by means of additional damping elements can induce less uses than a fall onto a rigid fundament from a height of 9 m. When the empty flask is lifted up to a height of approximately 20 m above ground floor or the loaded flask is lowered from this height, it must not damage any important system of the NPP -for the case of a fall. This requirement can be fulfilled by the arrangement of safety relevant measures within the transport area (e. g. damping equipment) or by exclusion of such an accident by design of the complete load chain (Gantry crane, horizontal lifting beam and flask trunnions) due to the increased requirements of the KTA 3902, 3903 and 3905.

- **Horizontal transport**

The lorry, the rails and the lock are designed against the load of a loaded flask. A fall from this low height would not effect unacceptable situations.

- **Transport into and out of the storage pool**

This is the most safety important step for the integrity of the NPP. A drop could damage the

- spent fuel elements in their racks in the pool with the risk of criticality
  - criticality or - release of radioactive material

- floor of the storage pool with the risk of
  - loss of cooling
  - loss of fuel element integrity
  - release of radioactive material.

Therefore a fall of the flask or the flask lid into the pool must be excluded. This aim can be reached by design of the complete load chain (reactor building crane, vertical lifting equipment, flask trunnions) according to the increased requirements of the KTA 3902, 3903 and 3905 and by administrative regulations with additional quality assurance steps. For each step there exists a procedure for the staff as part of a sequence step plan.

Loading

For the loading procedure it is necessary that the irradiated HLW is loaded regulary into the flask (e.g. GNS-M II Flask is equipped with special basket or GNS M 80 T flask with racks). This can be guaranteed by a preconditioning of HLW (according to KTA 3604) and/or a loading plan and quality assurance steps (4-eyeprinciple).The measures to prevent a load drop are mainly that the technical devices are designed and performed due to the increased requirements of the KTA 3902, 3903 and 3905 for all the handling equipment (reactor building crane, auxiliary hoist of refuelling machine, lifting equipment, load attachment points of baskets and racks). Further the handling steps are fixed in the sequence step plan with additional quality assurance measurements.

Measures from Additional and increased requirements of KTA 3902, 3903 und 3905

The important design safety measures for the technical equipment in according to KTA 3902, 3903 und 3905 in comparison to general conventional equipment are:

- Classification (additional or increased requirements)
- Additional load factors for dynamic effects
- Construction measures (e. g. Redundant hoist or safety brake) (see Fig. 5)
- Special materials test sheets and materials tests

- Detailed strength calculation
- Specific requirements for manufacturer
- Non destructive test
- Load test
- Inservice inspections
- Failure reportings systems from all NPP

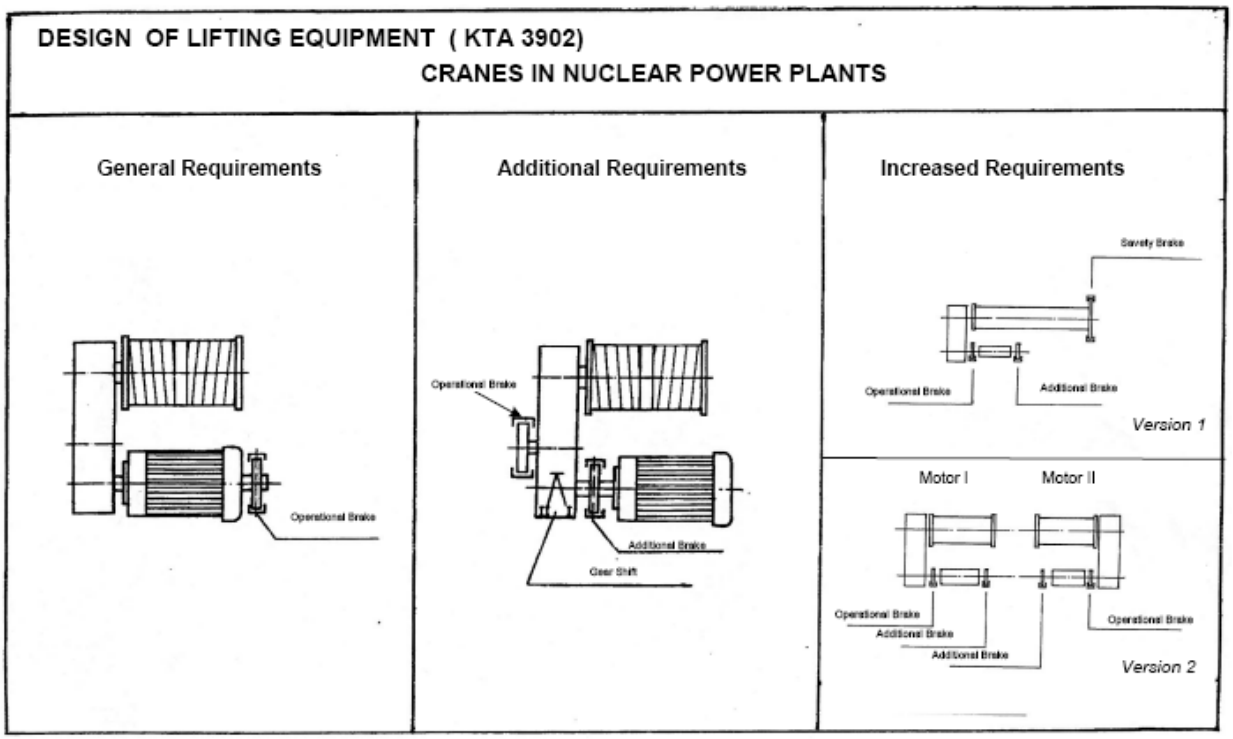

FIG. 5. Examples for Crane Hoist Design

Additional Safety Measurements

In addition to the above mentioned measurements the following safety actions at the NPP are performed:

- Additional contamination protection by special flask surface preparation (paint, seals)
- Additional quality assurance steps (flask drying and leckage test)
- Checking of minor handling tools (grippers)
- Administrative steps (4-eyeprinciple)
- Additional checks of removable contamination
- Quality documentation

Conclusion

Handling and transport of HLW flasks in a NPP involve risks for the NPP. Therefore all safety important handling-and transport steps must be analysed very intensively and performed with a very high safety standard according to suitable procedures based on detailed step and quality assurance-plans. For this purpose necessary a. m. regulations to fulfil the requirements are available. In Germany the execution of the handling steps and the state of the equipment including the flask are checked by independent experts who confirm the fulfilment of the requirements as one basis for the approval of the competent local authority. Good experiences up to now show the suitability of the procedures.
Up to now no heavy accident happened during handling and transport inside the German NPP-area. The fixed requirements has proven the suitability to assure safe handling now and in future.

References:

1. German Atomic Act (20th Issue)

2. KTA 3602 Storage and Handling of Fuel Elements with related Equipment in German NPP (Issue 11/03)

3. KTA 3604 Storage and Handling of Rad. Active Material (with Exeption of Fuel Elements) in German Nuclear Power Plants (NPP) (Issue 11/05)

4. KTA 3902, 3903 and 3905 Design, Inspection, Testing and Operation of Lifting Equipment and Load Attaching Points on Loads in German Nuclear Power Plants (Issue 6/99)

5. Regulations for the Safe Transport of Radioactive Materials, 1967 Edition 99, No. 6, IAEA

6. IAEA-Regulations fort the Safe Transport of Radioactive Materials:
   Safety requirements: Regulations for the safe Transport of Rad. Act. Materials TS-R1 (1996)