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"Current Handling of Transport- and Storage Flasks at German Intermediate Storage Plants – Safety Aspects"

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Abstract

In 2010 the Recommendations for Guidelines on the 10 yearly Periodical safety assessments of Intermediate Storage Plants (ISP) for spent nuclear fuel and heat supplying radioactive waste (L 1) were published new. Hence the most unfavorable load drop situations had to be investigated. A huge number of investigations had to be done, with the risk of results which are not assessable. As this could have caused a delay on the time schedule of the necessary disposal of spent nuclear fuel from German NPP, most of the German NPP and ISP operators decided to take the alternative possibility that is given in the Guidelines of the Reactor Safety Commission (RSK) (L 2) or which is also regulated within the Atomic accident guidelines for German PWR (L 3), to design the complete Load Chain (ISP-Crane, Lifting beam and Load attaching points (LAP) of the flask) according to the increased requirements of the KTA Standards 3902 and 3905.
A lot of consequent measures (e. g. Crane Reconstruction, Changes in administrative regulations) had to be done at the ISP. This paper shows the different phases of the reconstruction from the flashpoint to the approval process, the details of successful realization of the consequence measures, the involved parties and it focuses some interesting design measures of the most complex part of the load chain, the ISP-Crane.

Introduction

In 2010, the operators of the German ISPs Grafenrheinfeld, Isar, Grohnde, Unterweser and Brockdorf, which are in general the utilities, decided to do reconstructions of the lifting equipment of their facilities, although the erection of the storage buildings was not longer than ten years ago. What was modified in detail and what are the reasons for the redesign measures?

TÜV SÜD Industrie Service was called in by the licensing or supervisory authority (BfS) as an authorized inspector in accordance with § 20 of the Atomic Energy Act for the technical assessment and testing of the modifications of the cranes in Grafenrheinfeld and Grohnde.

Current regulatory situation

The storage of radioactive material and spent fuel in Germany is governed by many regulations (laws, decrees, guidelines and standards) in order to ensure the safety of workers, the public and the environment against operational and accidental release of radioactive material. This is an overview of the concerned parties, the correlations between them and the impact they have on the operation of an ISP:

ISP Operators

As the producer of the spent fuel and radioactive waste, the utilities (EVU) are responsible for the radioactive waste management, which means its storage and disposal. They are responsible for the design, construction and operation of ISP and decide about time, place and concept for the application for license for ISP at the Federal Office for Radiation Protection (BfS).

BfS: Federal Office for Radiation Protection

Based on § 6 of the atomic energy act, the BfS is the competent licensing authority for the storage of spent fuel elements and heat supplying radioactive waste in ISP.
The license for the storage of nuclear material had to be modified because of the application for the redesign of the ISP cranes. It is a specific feature of this matter, that within the scope of the new license, not only the design approval is covered but also the review and the final inspections of the cranes are included.

BAM: Federal Office for Material Testing

The BAM is competent for the mechanical and thermal testing for the licensing of the Transport- and Storage Flask (e.g. CASTOR® V) according to traffic law requirements (IAEA Regulations: TS-R-1). They published the 'Guidelines for the Calculation of Covering systems and Load Attaching Systems of Casks for radioactive Material' (BAM-GGR 012, Nov. 2012, only in German language (L 4)), which is basis for the KTA-Standard 3905.

RSK: German Reactor Safety Commission

The RSK published the 'Guidelines for Dry Intermediate Storage of spent Fuel Elements in Flasks' (Jan.2003) (L 2.)

- A handling accident (load drop during a handling action) is a load case which is relevant for the design of the flask.
- The design of the lifting equipment has to fulfill the requirements of the KTA Standards 3902.

But: if the design of the complete Load Chain (ISP-Crane, Lifting beam and Load attaching points of the flask) fulfills the increased requirements of the KTA Standards 3902 and 3905, chapter 4.3, a Load -drop caused by assumed crane-failure doesn't have to be regarded (risc < 10^{-6}/a).

ESK: German Safety Commission for Disposal of Radioactive Waste

The ESK published the Recommendations for Guidelines on Periodically Safety Analysis for Intermediate Storage Plants for spent Fuel Elements and Heat Supplying Radioactive Waste (July 2013) (L 1.)

- Basic safety element for operating the ISP is the proper design of the Transport- and storage flask regarding all operational and accidental loads.
- Present and former need of the TLB-license as a Package for Nuclear Materials following the transport regulatory requirements: The transport of the TLB on public transport routes after long term storage (40 years) must be possible, e. g. to the Final Storage Plant.
- With regard to the handling of the TLB, the cask itself has to fulfill all safety-related requirements for the enclosure and retention of radioactive material (not the building!).

Crane and flask manufacturers

The Crane and flask manufacturers are responsible for the design, construction and manufacturing of the ISP cranes handling equipment and load attachment points of the flask according to technical regulations (e.g. KTA 3902, KTA 3905)

Technical inspection agencies (e.g. TÜV SÜD)
The technical inspection agency provides an authorized inspector, which is called in by the licensing or supervisory authority (BfS) in accordance with § 20 of the Atomic Energy Act for the technical assessment and testing of the cranes (and the modifications) and the load attaching points of the flasks.
The radiation protection experts evaluate the radiological consequences of a failure of the handling equipment / procedure in the environment and on the personal. Depending on these evaluation the categorization of the handling equipment (crane, load attaching point, load chain) can be done, which defines the quality requirements on it.
The handling procedures during normal operation are evaluated with respect to the radiation exposure of the personal. Hereby the dose limits of the German radiation protection ordinance are taken into account. In case of an avoidable radiation exposure of the personal, the handling procedures can be adjusted, e. g. using remote control handling of the crane.

KTA: Nuclear Safety Standards Commission in Germany
The Nuclear Safety Standards Commission consists of several working groups for the different subjects, which have the task to develop the KTA-Standards according to the state of science and technology.
The main objectives of the KTA-Standards can be found in the introducing sentence of the fundamentals, which is: 'The safety standards of the KTA have the task to specify those safety related requirements (for the lifting equipment), which shall be met with regard to precautions to be taken in accordance with the state of science and technology against the damage arising from the construction and operation of the facility in order to attain the protection goals specified in the Atomic Energy Act and the Radiation Protection Ordinance'.

For the ISP-crane and the load-bearing equipment (traverse), the KTA 3902, 'Design of Lifting Equipment in Nuclear Power Plants' is the relevant standard. It offers a classification with three possible levels of safety related requirements depending on the potential hazards of the foreseen load handling actions.

- Chapter 3: General provisions: lifting equipment shall be erected in accordance with the valid general safety regulations, especially the federal and state work protection regulations and the regulations of the official insurance institutions.
  Lifting equipment shall at least comply with the generally accepted engineering standards.
- Chapter 4: special provisions
- Chapter 4.2: Additional requirements
- Chapter 4.3: Increased requirements
  "Increased requirements" are demanded, if a failure of the lifting equipment is expected to lead to a criticality accident or to the danger of a release of radioactivity with a subsequent radioactive exposure in the environment of the nuclear power plant

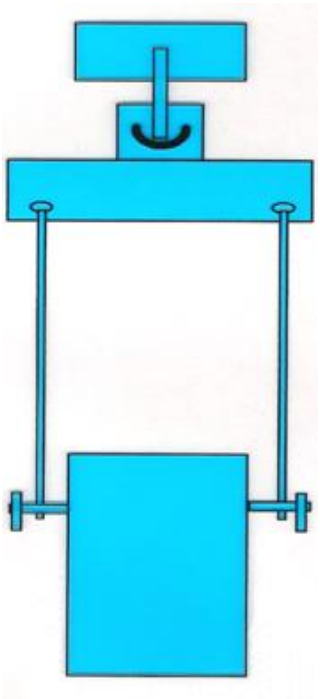
For the approval of the Lifting equipment, the KTA 3903, 'Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants' has to be applied.

For the load attaching points of the flask, the KTA 3905 ,Load Attaching Points on Loads in Nuclear Power Plants', which is structured in the same way as the KTA 3902, is relevant.

Load Chains in Intermediate Storage Plants

The load chains of the ISPs are considered to be the entirety of the lifting equipment used in the flask handling processes. In general, it consists of the crane, the load-bearing equipment

and the load attachment points of the flasks (see figure 1). Also, the transportation vehicle can be regarded as part of the load chain.



1 lifting equipment (KTA 3902, 3903)	**▪ steel construction and hoisting equipment of cranes or winches**
2 load-bearing equipment (KTA 3902, 3903)	**▪ handling beams, rigs ▪ ropes ▪ grippers**
3 load attaching points (LAP) (KTA 3905)	**▪ of flasks (e.g. CASTOR V) LAP-types: trunnions, lifting lugs, ring bolts, lifting eyes**

Figure 1. Load chain of the ISP-cranes

As a result of the design of the present cranes in the ISPs, the load drop of a transport and storage flask during handling actions with the main hoist or the auxiliary hoist had to be assumed up to now. For this reason, failure analyses for the handling of loaded transport and storage flasks were made, which resulted in proofs for the controllable consequences of an assumed load drop. Additional measures were taken, like:

- The use of concrete with shock absorbing material property in the loading area,
- The design of the traverse according to the 'increased requirements' of the KTA 3902 to prevent a diagonal load drop and
- The limiting of the lifting height above the floor of the storage area for the transport of a flask to the storage area and back.

Reasons for the Redesign of the Load Chains in ISPs

In 2010 the 'Recommendations for Guidelines on the 10 yearly Periodical safety assessments of Intermediate Storage Plants for spent nuclear fuel and heat supplying radioactive waste' (L 1) were published new. In L 1 it is emphasized that the basic safety element for operating the ISP is still the proper design of the Transport- and Storage Flask (TLB) regarding all operational and accidental loads. Also the decline of the Transport Approval Certificate of the mostly used German spent nuclear fuel TLB package type CASTOR V had to be considered in this period.
On these both occasions a new set of handling accident conditions were discussed. Additional load drop situations for the Revalidation and Relicensing of the TLB flask CASTOR V had to be assessed. Hence the most unfavorable load drop situations had to be investigated. Already the overall and general discussions showed a large number of different drop situations to be analyzed, especially during flask handling with the transport vehicle in the transfer area of the storage building.

All these load drop analyses shall show that the CASTOR V flask may maintain the required high margins for safe enclosure of the radioactive material. A huge volume of investigations had to be done, with the risk of results which are not assessable. This could even influence the time schedule of necessary disposal of spent nuclear fuel from German NPP.

Most of the German NPP and ISP operators therefore decided to take the alternative possibility that is given in the Guidelines of the Reactor Safety Commission (RSK) or which is also regulated within the Atomic accident guidelines for German PWR (L 3). Following these regulations the design of the complete Load Chain (ISP-Crane, Lifting beam and Load attaching points of the flask) has to fulfill the increased requirements of the KTA Standards 3902 and 3905.

Redesign Measures for the Load Chains in ISPs

The cranes in the intermediate storage plants had to be redesigned in a way that they fulfill the 'increased requirements' of the KTA 3902 completely (sole exception is the auxiliary hoist). Specifically, some of the "increased requirements" (according to KTA 3902 Chapter 4.3) compared to the conventional design of lifting equipment should be mentioned as an example:

- Hoists shall be equipped with a double drive mechanism chain or with a single drive mechanism chain with a safety brake.
- Redundancy is required for most of the mechanical components in the load path.
- From the high basic lifting and stress categories H4/B4, a high lifting factor of about 1.4 is derived.
- For crane vibration effects you have to count a coefficient of 2 for the machinery design.
- Compared to the general provisions, much higher load factors and safety values must be applied for the static calculation and the fatigue design.

To fulfill these requirements, a number of components of the ISP cranes had to be modified:

Mechanical Equipment:

- Load support structures (Bridge, Trolley)
  KTA 3902- chapter 4.3:which means basic lifting and stress categories H4/B4 according to DIN 15018
- Main Hoist: KTA 3902- chapter 4.3
- Auxiliary Hoist: KTA 3902- chapter 3
- Travelling gears: KTA 3902- chapter 4.3

Electrical Equipment:

- Travelling gears (new motors)
- Main Hoist:
  KTA 3902 – chapter 4.2, 6.5, 7.5 (safety brake with monitoring of gear rupture)
  Installation of a storage-programmable logic controller SPS S7 – 3
- Auxiliary Hoist : KTA 3902 – chapter 3, (general provisions)
- Renewal of the power supply

In addition, lifting equipment had to be designed against external events, if such requirement also existed for the building. Therefore, the approval procedure according to KTA 2201.4 "Design of Nuclear Power Plants against Seismic Events" had to be applied in the current version. In case of an earthquake, the crane is assumed to be in the parking position and without load.

Other consequent measures were modifications of administrative regulations at the ISP (e. g. the implementation of an in-service load test of the load attaching points of the transport and storage flask before the application for transportation to the final storage plant).

Approval process for the redesign of the ISP-cranes

The entirety of the approval process for the modifications of the cranes is shown in table 1. It can be divided into three phases, which all have to be completed and approved by certificate, before the following one is started.

	Phase I: „Design approval“	**Phase II: „Final Inspection“**	**Phase III: „Acceptance testing“**
Concerned Parties	NPP Utility, Industry (Manufacturer) Experts/ Authority	NPP Utility, Industry (Manufacturer) Experts/ Authority	NPP Utility, Industry (Manufacturer) Experts/ Authority
Documents to be generated	**Documents for design approval**	**Documents for final inspection**	**Documents for acceptance testing**
Contents	– Construction drawings + parts List – Calculations – Documents regarding electrical equipment – Material test sheets – Welding procedure specifications – Test and Inspection sequence (Final Inspection and Acceptance Testing) – Operating and maintenance instructions	Carried out and documented according to the approved test and inspection sequence for the final inspection – Construction drawings + parts list – List of material and related certificates – Welding procedure specifications – Test and inspection sequence (Final inspection and testing)	Carried out and documented according to the approved test instructions and the test and inspection sequenceplan for the acceptance test – Operating and maintenance instructions
Evaluation Standard	KTA 3902, 3903 Deviations	certified VPU Deviations	certified VPU Deviations
Verification/ Results	TÜV SÜD Expert's Report on design approval Certification of design approval	TÜV SÜD - Certification of final inspection - Expert's report on deviations	TÜV SÜD Certification of acceptance test Expert's report on deviations

Table 1. Approval process for the modifications of the ISP-cranes

The review documents have to be issued as required in the KTA 3902, chapter 5, and submitted to the consulting expert for review. The qualification of the manufacturer must be confirmed according to KTA 1401 “General Requirements Regarding Quality Assurance”. The applied materials must be qualified by the use of material test sheets.
Measurements for approval of electromagnetic compatibility were made.

Project specials

- Evaluations of safety relevant aspects at the dismantling and the reinstallation of existing cranes and interactions with the operation of the ISP were made.
- Frequent meetings for technical discussions with the licensing authority were called in.
- Dismantling and reinstallation of the cranes was carried out as it was planned, and without serious problems.
- Accordance of the calculated stopping distance of the safety break with the real values during the acceptance test/putting into operation /IBS caused some problems
- Measurements for the approval of the electromagnetic compatibility were made.
- The operators' manual, including the operating and maintenance instructions and the in-service inspections were also modified, reviewed and approved.
- The complete process was finalized with an expert‘s report without open items.

- Partially experts associations were made (Expert consortium, TÜV SÜD, TÜV NORD, TÜV Rheinland).

Conclusions

- Licensing Authority according to § 6 AtG is the BfS. The license for the storage of nuclear material had to be modified for the modification of the cranes.
- Specific feature of the license: Design approval and final inspections of the cranes are included in the scope of the license
- Considerations for the Redesign of Load Chains were:
    - The existing cranes do not fulfill the requirements of the KTA 3902, chapter 4.3 (increased requirements, supposed load drop, etc.)
    - Decline of the Transport Approval Certificate of CASTOR® V
    - Additional load drop situations for the Revalidation and Relicensing of the flask CASTOR® V have to be assessed.
    - Influence on the time schedule of necessary disposal of spent nuclear fuel from German NPP.

  ISP-Operator‘s decision: new cranes with KTA 3902, chapter 4.3-conformity instead of a lot of case-studies with uncertain results.
- The modifications of the cranes were carried out according to the „increased requirements” of the KTA 3902, chapter 4.3
- Putting into operation and acceptance tests were made under supervision of the authority according to the atomic act.
- Dismantling and reinstallation of the cranes were carried out without serious problems.

References

L 1. German Safety Commission for Disposal of Radioactive Waste (ESK)
Recommendations for Guidelines on Periodically Safety Analyses for Intermediate Storage Plants for Burnt Fuel Elements and Heat Supplying Radioactive Waste (Nov. 2010)

L 2. German Reactor Safety Commission (RSK)
Guidelines for Dry Intermediate Storage of Burnt Fuel Elements in Flasks (Jan. 2003)

L 3. RSK/BMU-Guidelines for Atomic Accidents in German PWR (Oct. 1983)

L 4. Bundesanstalt für Materialforschung und –prüfung (BAM)
BAM-GGR 012, ‚Leitlinie zur Berechnung der Deckelsysteme und Lastanschlagsysteme von Transportbehältern für radioaktive Stoffe‘ (Nov. 2012)