# Safety Analysis of "Older/Aged" Handling and Transportation Equipment for Heavy Loads, Radioactive Waste and Materials in Accordance with German Nuclear Standards KTA 3902, 3903 and 3905

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## ABSTRACT

The purpose of this paper is to present a general safety analysis of important handling and transportation processes and their related equipment ("load chains" consisting of cranes, load-bearing equipment and load-attaching points). This project was arranged by the responsible Bavarian ministry for environment, health and consumer protection (StMUGV) in agreement with the power plant operators of all Bavarian nuclear power plants to work out potential safety improvements.

The range of the equipment (e.g. reactor building, crane, refuelling machine, load-bearing equipment and load-attaching points) covers the handling and transportation of fuel elements (e. g. with fuel flasks), heavy loads (e.g. reactor pressure vessel closure head, shielding slabs) and radioactive materials and waste (e.g. waste flasks, control elements, fuel channels, structure elements). The handling equipment was 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[1] (3902, 3903 and 3905) was examined.

The higher protection aims "safe handling and transportation of heavy loads and safe handling of radioactive materials and waste" of the whole analysis are to avoid a criticality accident, the release of radioactivity and inadmissible effects on important technical equipment and buildings. The scope of the analysis was to check whether these protection aims were fulfilled for all important technical handling and transportation processes. In particularly the design and manufacturing of the components and the regulations of the handling itself were examined.

## ABBREVIATIONS

| | |
|---|---|
| AtG | Atomic Energy Act |
| BE | Fuel assembly |
| BHB | Operation manual |
| EDP | electronic data processing |
| KKI 1 | Nuclear power plant Isar unit 1 |
| KKI 2 | Nuclear power plant Isar unit 2 |

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[1] See Ref. 1., 2. and 3.

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| KKG | Nuclear power plant Grafenrheinfeld |
| KRB II B und C | Nuclear power plant unit B and C |
| KTA | Nuclear Safety Standard Commission |
| KSD-sheet | Component-data sheet |
| LAE | Load-bearing equipment |
| LAP | Load attaching points |
| MTO | Human, engineering and organization |
| OFR | Surface crack examination |
| PHB | In-service inspection manual |
| SÜ | Safety analysis |
| RDB | Reactor pressure vessel |
| SSA | Safety status analysis |
| StMUGV | Bavarian ministry for environment, health and consumer protection |
| TMI | Three Mile Island |
| TSO | Technical Support Organisation |
| WKP | In-service inspection |

## INTRODUCTION

Quite recently the human contribution and the organizational measures are considered to be part of the efforts towards another safety optimization in nuclear technology to guarantee a higher level of safety. Following the international experiences from the operation of nuclear power plants, approximately 2/3 of all events can be traced back to human failure or inadequate organizational integration into the operational process[2].

Mistakes are usually caused or made more likely by defects in the area of human-technology interfaces and organization. In the early eighties nuclear technology safety was checked mainly from a strongly technically point of view. Events such as Three Mile Island (TMI) in 1979 and Chernobyl in 1986 changed this understanding. It was recognized that the human aspect plays a non-negligible role and that the reciprocal effect between technical and human aspects represents an important subject in nuclear technology. The factors human, technology, organization (MTO) and their reciprocal effects have since then changed the point of view[3].

On account of the experience gained from many years of operation of nuclear power plants, handling and transportation processes were identified as an area where improvements are possible in this respect.

To analyse the problem of the MTO reciprocal effects in the operational practice of nuclear power plants, and to work out potential safety improvements, the StMUGV in collaboration with the power plant operators of all Bavarian nuclear power plants has arranged an integrated consideration of handling and transportation processes and their related equipment on the basis of a general safety analysis. The required extensive examinations were made by the power plant operators and proofed and valued in expert statements by the TÜV Industrie Service GmbH (TÜV SÜD Group) as an Technical Support Organisation.

[2] See Ref. 4.
[3] See Ref. 4. and 5.

# INTEGRATED SAFETY ANALYSIS IN THE OPERATIONAL PRACTICE OF BAVARIAN NUCLEAR POWER STATIONS[4]

## Preconditions and Objectives

The integrated safety analysis ran independently of the normal operation of nuclear power plants and was executed as a supplement to the safety status analysis (SSA) that represents a component of the "safety analysis (SÜ)" and is to be implemented in accordance with § 19a of the German atomic energy act (AtG) in a temporal interval of ten years.

The following practical aims were identified:

- One important target was to assess the fulfilment of higher protection aims that arise from the applicable KTA standards 3902 and 3905 and the requirements for the equipment derived from it. The higher protection aims for the "safe handling and transportation of heavy loads and safe handling of radioactive materials and waste" are to prevent:
  - a criticality accident,
  - the release of radioactivity and
  - inadmissible effects on important technical equipment.

  The dependence of the respective design and construction qualities of the handling and transportation equipment of the above mentioned protection aims are specified in detail on the basis of the classification in safety / requirements categories in accordance with the KTA standards 3902 and 3905.

- Technical aspects (i.e. particularly the design and the construction) and also organizational aspects (i.e. the integration of the handling and transportation processes in the operational expiration) were taken into consideration.

- In particular, the aspects of the fuel element handling, the handling of heavy loads and radioactive materials and wastes should be examined in this safety analysis. The handling and transportation equipment in operation were examined taking into account the ageing of the equipment and the progress of standards. The compliance of the current valid requirements of the state of science and technology and particularly of the nuclear safety KTA-standards[5] (3902, 3903 and 3905) were examined. According to the b. m. KTA standards the respective specific requirements for the handling and transportation equipment are derived.

  KTA-standard 3902: Design of Lifting Equipment in Nuclear Power Plants, Issue 06/99.

  KTA-standard 3903: Inspection, Testing and Operation of Lifting Equipment in Nuclear Power Plants, Issue 06/99.

  KTA-standard 3905: Load Attaching Points in Nuclear Power Plants, Issue 06/99.

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[4] See Ref. 6. and 7.

[5] See Ref. 1., 2. and 3.

## General, Content and Scope of the Analysis

The safety analysis on important handling and transportation processes and their related equipment was conducted during 1995 to 2005 for the following four Bavarian nuclear power plants:

1. Nuclear power plant Isar 1 (KKI 1): boiling water reactor 900 MW
2. Nuclear power plant Grafenrheinfeld (KKG): pressurized water reactor 1.300 MW
3. Nuclear power plant Gundremmingen (KRB II Block B und C): boiling water reactor 2 x 1.300 MW
4. Nuclear power plant Isar 2 (KKI 2): pressurized water reactor 1.300 MW

The analysis essentially distilled in the following documents:

The basis of this safety analysis is explained and its scope defined in the so-called, "scribbling-report", in which all important handling and transportation processes were registered in tabular form and were classified according to their design and construction quality in accordance with the KTA standards 3902 and 3905.

The central point of the safety analysis was a so-called "standard comparison". Within this comparison the current valid requirements from the a. m. technical standards were compared with the as built / as designed state. In particular the construction / manufacturing, the mechanical calculation, the documentation and the integration of the handling equipment in the operational regulations of the nuclear power plant (e. g. by the operating manual or the in-service testing plans) were proofed.

## Classification Criteria

For a sufficient "damage provision" and dependent upon the respective design and construction quality of the handling and transportation equipment the following requirements for the equipment can be derived according to the KTA-standards 3902 and 3905:

1. **General basic requirements (cf. KTA-standards 3902 und 3905, paragraph 3.0)**
   a) 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 accident insurance institutions.
   b) Lifting equipment and LAP shall at least comply with the generally accepted engineering standards.
2. **Additional requirements (cf. KTA- standards 3902 und 3905, paragraph 4.2)**

   The equipment shall be designed according to the additional requirements if a failure of the equipment (consequences from a load drop) leads to
   a) the immediate danger of a release of radioactivity with a subsequent radioactive exposure in the plant or
   b) a loss of reactor coolant which cannot be isolated, or
   c) a redundant overlapping effect of the safety equipment which is necessary to shut down the reactor at any time, to maintain the reactor in the shutdown condition or to remove residual heat.
3. **Increased requirements (cf. KTA-standards 3902 und 3905, paragraph 4.3)**

   The equipment shall be designed according to the increased requirements if a failure of the equipment leads to
   a) a criticality accident or

b) the danger of a release of radioactivity with a subsequent radioactive exposure in the environment of the nuclear power plant.

We conducted a risk analysis of the transmission of a. m. requirements (to the equipment) taking into account the specific circumstances of the nuclear power plants. The result is represented in fig. I in form of a decisive matrix. The necessary requirements with respect to classifications were derived by the definition of important "handling areas" in the nuclear power plants, the consideration of the weight of the equipment and the transportation height for the handling processes in accordance with the KTA standards 3902 and 3905.

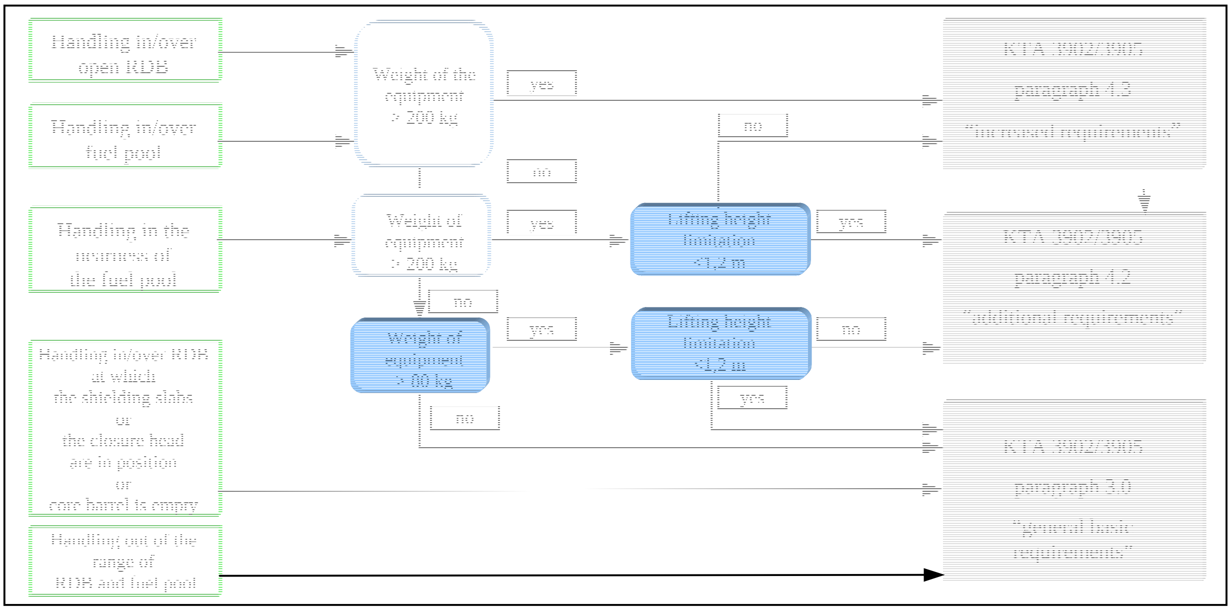


Fig. 1. Classification criteria for handling and transportation processes derived from the requirements of KTA standards 3902 and 3905

## Phases concept

The procedure of the safety analysis which is illustrated in Fig. 2 can be subdivided into a "four phase concept":

phase I: Listing and classification
phase II: Evaluation and detailed verification of documents
phase III: Conversion of actions
phase IV: Final report

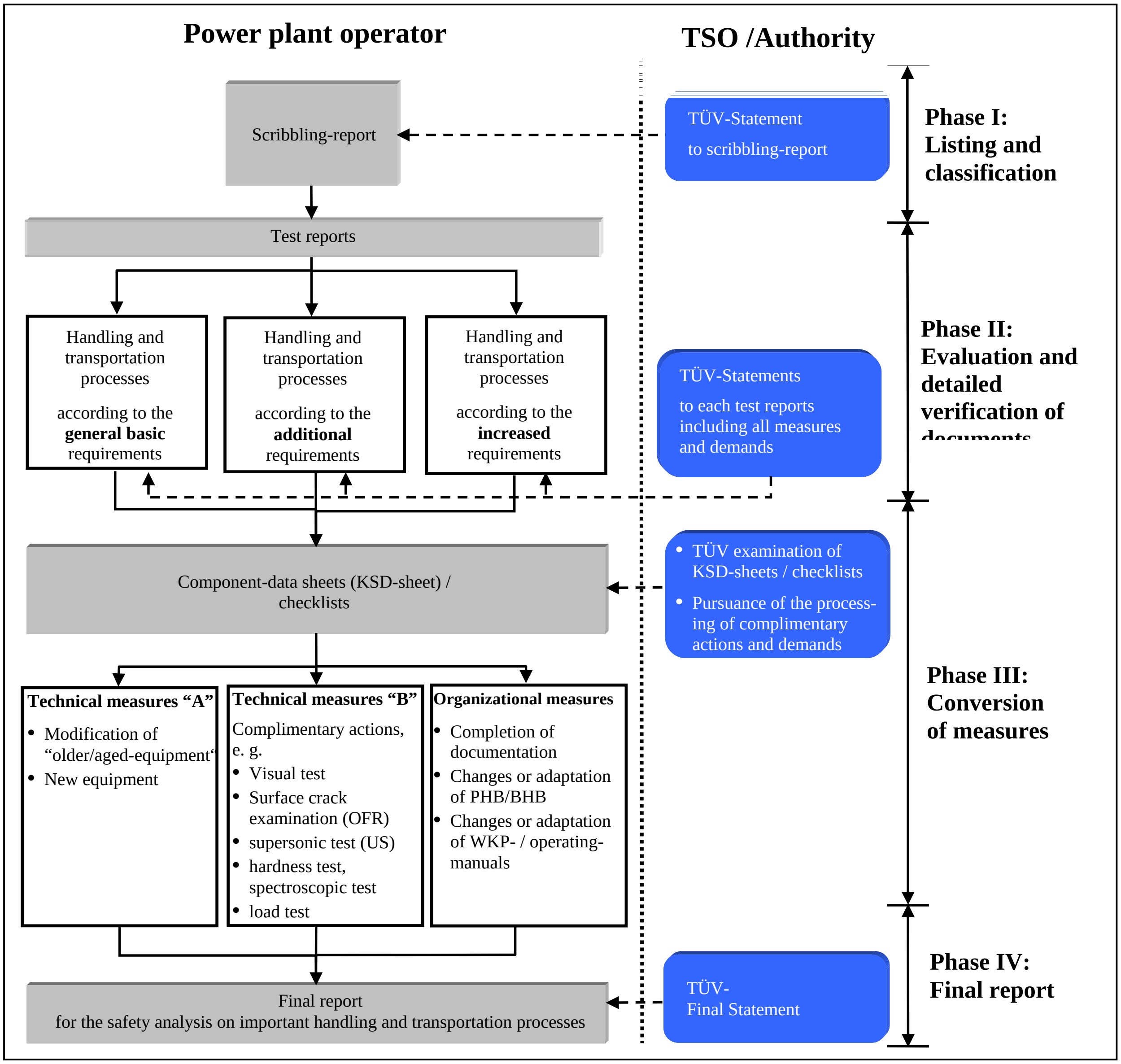


Fig. 2. Overview of integrated safety analysis

## Phase I: Listing and Classification

The individual safety classifications according to the paragraphs 4.2 and 4.3 of the KTA standards 3902 and 3905 are fixed for the essential handling and transportation processes within at the first phase of the safety analysis in the scribbling-report by consideration of the a. m. consequences of a postulated failure of the equipment of the “load chain”. In Fig. 3 a term "load chain" is shown schematically.

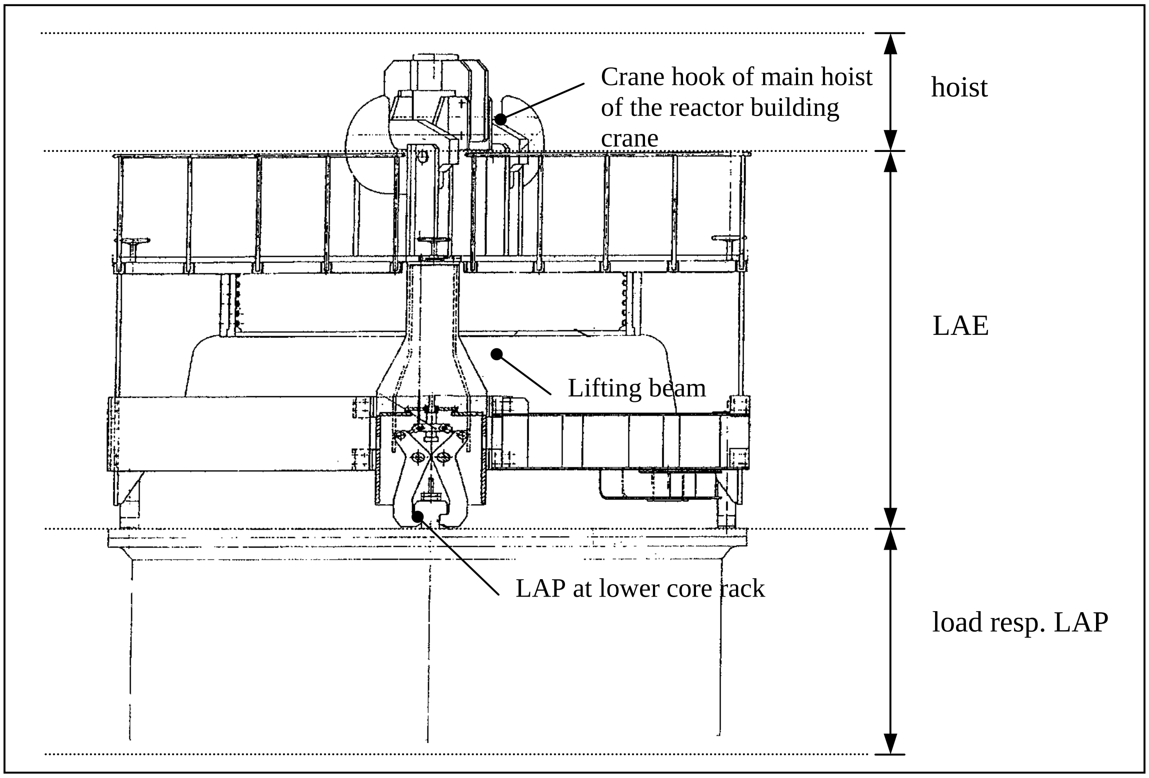


Fig. 3. “Load chain” description on the example of the lifting beam for the lower core rack

## Phase II: Evaluation and detailed verification of documents

In the second phase, the preparation of the individual test reports to each handling and transportation process and the equipment of the “load chain” was performed. By investigating and verifying in detail the individual test reports and the documentation from manufacturing, the design and the construction of the handling and transportation and the equipment of the “load chains” (i.e. lifting gears, LAE and LAP) were checked for observance of the requirements of the standards.

The main points considered in the test reports are represented in Table. I:

Table I. Detail Guidance and Main Points of the Test Reports

| Description of the handling processes | Comparison with KTA-standard | Evaluation of the stated deviations and suggestions for complimentary measures |
|---|---|---|
| ▪ Short description of the handling process<br>▪ Description of the transport path and statements<br>o to the frequency of the transportations,<br>o max. possible drop height and<br>o to special occurrences.<br>▪ Description of the “load chain” (overview drawing, design data, e.g. classification, loads, boundary conditions, load-carrying capacities or design specifications).<br>▪ Administrative definitions to the handling process, as for example handling instructions, step consequence plans, operation manual (BHB), etc. | ▪ In particular the constructive execution, the design, the documentation and the integration of the handling equipment were examined in the operational expiration of the nuclear power plants (e.g. by the BHB, the test manual (PHB) or the test instructions for WKP vs. the current valid requirements of the KTA-standards. | ▪ The design deviations which result from above mentioned standard comparison were evaluated and it was determined whether or not complimentary measures were necessary. |

In accordance with the guidance in Table I, the following exemplary division arises for the test reports for each handling and transportation process:

1. Short description of the handling process and the transport path
2. Description of the handling process and their individual equipment (crane/hoist, LAE, LAP)
3. Design data for the handling process and their individual equipment
4. Determinations, administrative definitions, BHB, frequency of the transportations
5. Operating experience
   5.1 Periodical inspections
   5.2 Reportable events, operational experience
6. Classification of the equipment of the “load chain”
7. KTA-comparison (3902, 3903 and 3905)
   7.1 Type “A” (design conditions including the calculation)
   7.2 Type “B” (for material, preliminary, acceptance and periodical tests)
8. General view of the deviations with specified measures

Within the test reports the comparisons with the KTA-standards represent the fundamental examination. The KTA-comparisons were produced as a type “A” and type “B” comparison in which the observance of the current valid requirements of the nuclear safety standards (3902, 3903 and 3905) were compared with the original design conditions at manufacturing. In the type “A” comparison in particular the general design data and the calculation were verified. On the other hand, in the type “B” comparison the manufacturing design and construction of the equipment involved in the respective processes was examined.

From phase II the following mainly complimentary measures arise:

- New devices
- Construction unit changes
- Non destructive checks, e. g. visual test, surface crack examination, supersonic test, hardness test, spectroscopic test, load test, etc.
- Changes or adaptations of the operating manuals, the periodical inspection plans or the handling manuals and operating instructions.

### Phase III: Conversion of Measures

Continuing from the derived actions in the second phase, the conversion of the design deviations is now the main point.

The complementary measures in the test reports as well as supplementary demands from the TÜV statements were integrated in the form of a checklist in so-called KSD-sheets. The pursuit and processing of the open points or complementary measures took place on the basis of the checklist in the KSD-sheet.

### Phase IV: Final report

In the final report of the safety analysis as the last phase of this integrated analysis a general evaluation is carried out.

## SUMMARY AND OUTLOOK

A high-quality technical execution and a good engineering knowledge based on technical standards are a necessary, but insufficient presupposition, to reach a high safety level in nuclear power plants. It is also important to pay attention to the organizational or human factors. The safety analysis applied to important handling and transportation equipment in Bavarian nuclear power plants has shown by an integrated consideration the reciprocal effect between technology and organization and at the same time demonstrated the strength and weakness of this conception. The adaptation of "older/aged” equipments to the current valid requirements of state-of-the-art science and technology and particularly to the nuclear safety standards KTA (3902, 3903 and 3905) has shown -taking into account the progress of standards- numerous safety improvements for equipment to support the operational expiration in the nuclear power plants.

By the fixed main points (cf. Table I) in the assessment guidance it was possible to get a transparent analysis of each handling and transportation process. The so-called KSD-sheets in which a short description and all relevant deviations / information related to each item of equipment was carried out, will enable all project partners (power plant operator, TSO and authority) to get a good view of the equipments and their border conditions with this short "One page representation" themselves in the future . These KSD-sheets that are already used by the power plant operators for internal training are considered as a life act of each individual equipment. An EDP sided implemention of the resulting information regarding all handling and transportation equipment, e.g., in a data bank, would be a good supporting instrument. The introduction of safety management-systems in nuclear power plants which would help the safe operation or the monitoring of the safety level by the evaluation of safety indicators as recently discussed in Germany can be implemented quickly and efficiently. Such safety indicators are, for example the annual number of the deviations or comments in periodical tests or not in time executed periodical tests.

The safety analysis executed here can be understood as a modification of the MTO concepts that are described in numerous variations in the literature. The main points in this modification were the reciprocal effects between technology and organization. The human aspects only appear in the organizational integration of the equipment in the operational expiration of the nuclear power plants.

In summary the involved parties in this project gave the positive statement that this kind of safety analysis performs an essential contribution to increase the safety as well as the "safety culture" in Bavarian nuclear power plants with respect to the progress of standards. In addition this project gives the power plant operators the possibility to realize a purposeful "modernization" in regard to possible long term continuation of their plants.

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