Current developments with respect to safety management in German NPPs

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Abstract:
The awareness of the significance of safety management for the safe operation of NPPs has increased in recent years. This is mainly due to the occurrence of some reportable events which revealed substantial deficiencies in safety management. Therefore, all operators of NPPs as well as the federal and state authorities started activities aiming to implement comprehensive and more effective safety management systems in the NPPs.
The paper describes the most important activities of the authorities and the nuclear power plant operators as well as the results achieved so far. Also, the current state of experiences and the conclusions drawn are discussed taking into account experiences in the non nuclear industry.

1 INTRODUCTION

Over the last years, some reportable events occurred in German NPPs, which showed significant deficiencies in safety management. These deficiencies concerned different aspects of safety management.
Also, the deregulation of the electric power market in the Federal Republic of Germany has led to a substantial cost pressure on operators. This resulted in organizational changes in German NPPs as well as in reduction of plant staff and streamlining of work processes.
Both developments have led to an increasing awareness of the significance of safety management for safe operation of NPPs. Particularly the reportable events have shown that considerable efforts are still necessary to implement a comprehensive and effective safety management.
Therefore, all operators of NPPs as well as the federal and state authorities started activities aiming to implement comprehensive and more effective safety management systems in the NPPs. This lecture will describe the most important development steps as well as the results achieved so far and will give an outlook on planned future activities.
The following chapter will give a brief survey of reasons and resulting activities during the last years in the field of safety management. Chapter 3 will describe the main activities of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Chapter 4 will deal with important activities of the plant operators. With respect to operator activities, emphasis will be placed on the development of an integrated management system by the operator EnBW. Chapter 5 will discuss the current state of experiences and draw conclusions taking into account experiences in the non nuclear industry.

2 SURVEY OF RECENT DEVELOPMENT OF SAFETY MANAGEMENT IN GERMAN NUCLEAR POWER PLANTS

In 1998, a transient occurred at a German NPP during which one out of four main steam safety and relief stations did not open when demanded. The event showed considerable deficiencies in the safety management of the plant. In particular, the investigations revealed that the deficiencies in safety management already existed for quite a long time before the event occurred without having been identified sufficiently or removed. As a consequence, the plant operator as well as the state authority discussed possibilities to measure and monitor safety performance in an adequate manner. Their goal was the early identification and correction of deficiencies in safety performance.

As a result, the operator in co-operation with GRS started to develop an indicator system on the basis of a process model. Early in the development, it became obvious that focussing on a pure indicator system involved some limitations. Therefore, the plant operator decided to develop and implement an integrated management system. This integrated management system contains safety management as an integral part.

In parallel to the development of an integrated management system, the operator introduced the "International Safety Rating System" (ISRS) and peer reviews at his NPPs as a short-term measure. Subsequently, the ISRS was enhanced in co-operation with the other German operators of NPPs and adapted to the specific requirements of NPPs. By now, it is used as safety culture assessment system (VGB-SBS) by all German operators. The peer reviews were also introduced by the other operators. Now, they are carried out as national peer reviews.

At about the same time when these developments started, BMU and the state authorities established a working group at the department head level. The aim of the working group was to monitor potential effects on safety of the NPPs resulting from the changing environment due to the deregulation and to take measures to maintain the safety level where required. Within the framework of this working group, BMU asked GRS to prepare a questionnaire to determine the current status of safety management at German NPPs.

In 2001, further events occurred at two other NPPs, which were also important for the development of safety management. In the first event which occurred in summer 2001, an NPP was started-up after refueling outage although the boron concentration was below the required limit in three out of the four refueling water storage tanks of the emergency core cooling and residual-heat removal system. The problem was discovered during power operation almost two weeks after plant restart. Although the plant had to be shut down immediately according to the plant operating procedures, power operation was continued. The second event happened about four months later in another German NPP. In this event a radiolysis gas explosion occurred in a pipe connected to the reactor pressure vessel. As a result, a part of the pipe inside the containment was destroyed completely. Based on a preliminary assessment carried out by the operator, power operation was continued. The containment was inspected only two months later. During this inspection, the damage was detected.

Both events showed considerable deficiencies in different areas of safety management of the plants. In response to it, BMU and the responsible state authorities demanded the implementation of a comprehensive safety management system at both plants. The plant operators concerned agreed and started to develop safety management systems.

At about the same time, all German operators of NPPs were requested to answer the BMU questionnaire about the current status of safety management. The answers showed that some elements of safety management were implemented at German NPPs. But, a comprehensive safety management system did not exist. As a consequence, BMU and the state authorities demanded the implementation of a comprehensive safety management system at all German NPPs. Furthermore, BMU and the state authorities demanded that a corresponding concept was to be submitted within half a year. The German operators agreed to it.

In parallel to this, BMU asked GRS to develop fundamentals of safety management systems at NPPs. The aim was to establish a standardized framework of requirements for safety management systems at NPPs and for their assessment by the authorities.
In the middle of 2003, the association of German operators (VGB) submitted the common concept of the operators for safety management systems at NPPs. On behalf of BMU, GRS prepared an expert opinion on this concept. In spring 2004, BMU published the "Fundamentals of Safety Management Systems at NPPs" prepared by GRS.
At present, an integrated management system based on a process model is being introduced at the Unterweser NPP (KKU). Important processes including process performance measurement have already been implemented. The development of an integrated management system for the NPPs of the operator EnBW is also at a very advanced state. The implementation of first processes for testing is planned for this year. The integrated management system is scheduled to be used in 2005.

3 REGULATORY ACTIVITIES

In the German nuclear rules and regulations there is a great number of single requirements related to safety management but there are no comprehensive requirements and assessment criteria. This raises the question what requirements safety management systems have to meet and how to assess safety management systems. This problem became particularly evident, after BMU and the state authorities demanded the implementation of comprehensive safety management systems in German NPPs.
Therefore, BMU decided to develop corresponding requirements. The aim is to ensure a nationwide standardized level of safety management systems at German NPPs and to provide standardized assessment criteria for these safety management systems. For this purpose, a step by step procedure was chosen. In the first step, the current status of safety management at German NPPs was determined. Based on this status, fundamentals of safety management systems at NPPs were developed and published. These activities will be addressed more detailed in the following. More detailed requirements related to important elements of safety management systems are in development. This issue will be briefly addressed in the last section of this chapter.
At present, extensive work is being conducted on behalf of BMU with the aim to update the German nuclear rules and regulations. Within the framework of this update, a set of comprehensive requirements on safety management systems shall become part of the nuclear rules and regulations.

3.1 Survey of the current status of the safety management system at German NPPs

In 2002, a survey of implementation and application of safety management at German NPPs was conducted by means of a questionnaire. This questionnaire was prepared in 2001 by GRS on behalf of BMU. The aim was to obtain a detailed survey of the current status and the practice of safety management at German NPPs.
In accordance with this objective, a comprehensive questionnaire with more than 40 questions was developed. Basis for structure and content of the questionnaire were the IAEA Safety Guide NS-G-2.4 and the INSAG reports INSAG-4 and INSAG-13. The questionnaire deals with all important aspects and elements of safety management according to INSAG-13, the relevant organizational procedures and tools as well as the activities which are subject to safety management. Further, the questionnaire also contained guidance for answering. In particular, this included specifications on expected scope and depth of the answers and the documents to be enclosed.
The questionnaire was agreed upon by BMU and the state authorities and submitted to all German plant operators for answering. The answers of the plant operators were largely

identical. Plant-specific information on the current status of safety management were only provided to a minor degree. The answers of the plant operators showed that some elements of safety management were implemented at the German NPPs. This concerned, above all, the areas for which requirements are laid down in the existing nuclear rules and regulations. Altogether, however, the answers showed that comprehensive safety management systems did not exist.

3.2 Fundamentals of safety management systems at nuclear power plants

When BMU and the state authorities requested the German operators to implement safety management systems at their NPPs, there was a need to provide a standardized framework of requirements for safety management systems and for their assessment by the authorities to ensure a common nationwide level and approach. Since the current update of the German nuclear rules and regulations will still take some time, BMU decided to publish a paper on the requirements for safety management at nuclear power plants. Therefore, BMU asked GRS in 2003 to develop fundamentals of safety management systems at NPPs.
This fundamental paper should contain a compilation of generic characteristics of safety management systems. In addition, it should include the relevant requirements for all important elements of safety management systems. Altogether, the fundamental paper is intended as a standardized framework for safety management systems, but, at the same time, it shall leave enough freedom to the plant operators for the design of their individual safety management systems.
The general procedure for the development of the fundamental paper is presented in Figure 1.

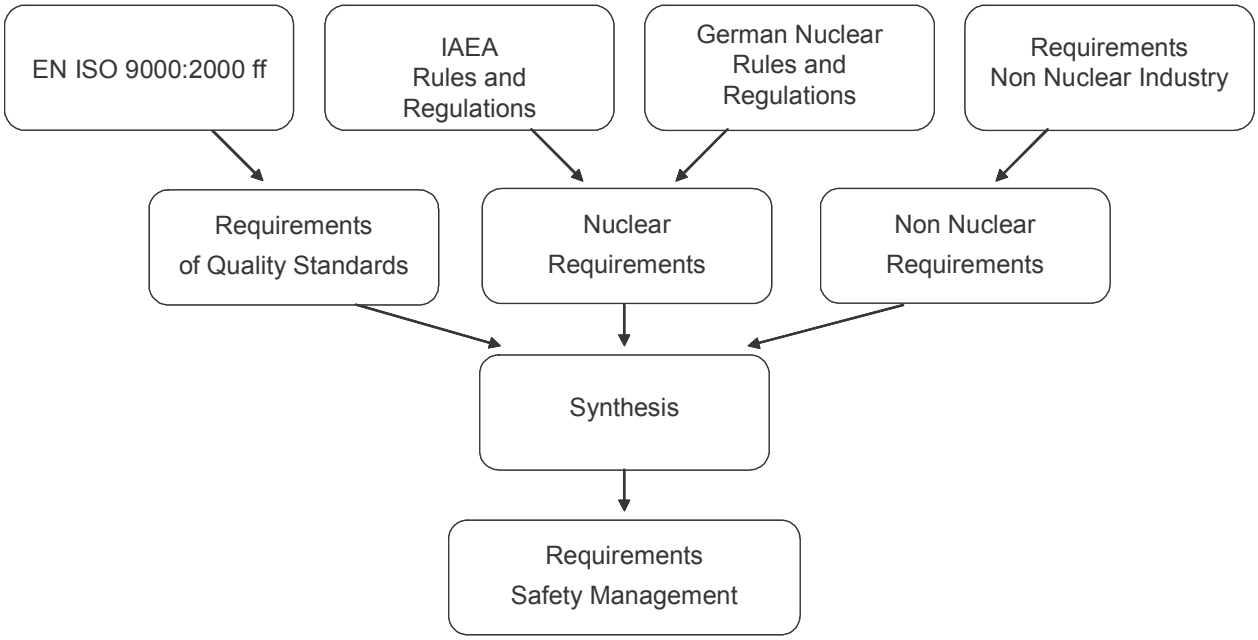

Figure 1: Procedure for the development of safety management requirements

The development of the fundamentals was based on the quality standard EN ISO 9000:2000 ff. The standard EN ISO 9000:2000 ff comprises the requirements for modern quality management systems. It has a broad scope of application (different business objectives). The standard is based on a closed-cycle management model which puts emphasis on planning and achievement of a high quality as well as on quality monitoring and improvement.

First priority of safety management is that all activities relevant to safety are performed with the required high quality. Accordingly, for the development of the fundamentals, the requirements of the standard EN ISO 9000:2000 ff were applied by analogy to the specific business objective "achievement of a high level of safety".
In a second step, these requirements were supplemented based on a comparison with the requirements for safety management systems in international nuclear rules and regulations (in particular NS-G-2.4 and INSAG-13) as well as in the German nuclear rules and regulations. This comparison did not reveal any inconsistencies between the requirements of EN ISO 9000:2000 ff and the requirements of the nuclear rules and regulations. In a last step, the safety management requirements were compared to those applied in the non nuclear industry. This did not reveal any need for modifications.
At present, the existing IAEA standard on quality assurance (IAEA 50-C/-Q „Code on Quality Assurance for Safety in Nuclear Power Plant“) is under revision. This revision is at a rather advanced stage. The current status can be found in the document "Draft Safety Requirements DS338 Draft 6, Management Systems“. GRS is involved in this revision. The draft of the new standard (DS338) is aligned with the standard EN ISO 9001:2000 ff. It is based on the concept of an integrated management system and a process-oriented approach. The requirements in the draft IAEA standard correspond to the requirements in the fundamentals published by BMU.
The main requirements stated in the fundamentals of safety management systems at NPPs are:

- The safety management system has to comprise all activities which might have a direct or indirect influence on safety.

- The implementation, operation, maintenance and improvement of the safety management system is task and responsibility of the top management and has to be coordinated by the latter.

- The safety management system should be a closed-cycle management system, i.e. effectiveness has to be monitored and improvements have to be identified and implemented.

- The safety management system is to be considered as an integral part of the integrated management system. Correspondingly, the delimitation and the interfaces as well as the interaction of the safety management system with other management systems have to be defined and regulated in an appropriate manner.

- The safety management system should be based on a process-oriented approach for modeling and assessing the work processes of the company.

- The plant management has to implement an organizational structure that is suitable with regard to safety.

- The safety management system does not only have to consider the nuclear power plant with its organization and processes but also all relevant areas of the company as far as they concern safety-related tasks and responsibilities, such as the provision of resources and personnel planning. Furthermore, the safety management system has to include the interfaces with external parties too.

- The safety management system has to be documented to a sufficient extent.

3.3 More specific requirements on some essential elements of safety management systems

Previous experiences with the development of safety management systems suggested to develop more specific requirements beyond the scope of the fundamental paper for some elements of safety management. Corresponding work is currently being performed by GRS on behalf of BMU. This work comprises the development of

- generic specifications for the elaboration of safety objectives and targets,
- criteria for the assessment of process models and related documentation,
- methods for the verification of completeness and effectiveness of indicators for the assessment of the safety management,
- criteria for the assessment of plant organization and organizational changes from a safety point of view.

The work is expected to be completed in 2005.

4 ACTIVITIES OF THE PLANT OPERATORS

The survey of the development of safety management in German NPPs in Chapter 2 shows that due to recent events some operators started to develop and implement a safety management system in their plants already very early. At first, this was the Unterweser NPP (KKU), later on the operator EnBW with its sites Neckarwestheim, Philippsburg and Obrigheim. Both pursue the approach of an integrated management system comprising the safety management as an integral part.
In parallel to these activities, according to the demand of BMU and state authorities to implement a comprehensive safety management at all German NPPs, a common concept of the operators for optimizing their safety management systems was developed at the level of VGB. The approach of the integrated management system goes beyond the concept of VGB and is pursued by the before-mentioned operators. The following section will describe the VGB concept. After that, the status of the work with respect to development and implementation of an integrated management system will be discussed taking the EnBW as an example.

4.1 VGB concept for optimizing the safety management system

In July 2003, VGB submitted its concept for the optimization of the safety management system to BMU and the state authorities. According to VGB, this concept is a joint concept of all German operators of NPPs. The concept is based on the assumption that a functioning safety management system already exists at German NPPs which might need some optimization. The concept describes necessary and suitable elements and tools of safety management and their interaction. The concept is intended as guidance for the NPPs.
The VGB concept understands safety management as a management process to which the closed management cycle is to be applied (Plan-Do-Check-Act cycle). The requirements in the VGB concept that have to be fulfilled by a safety management system were determined on the basis of the IAEA report INSAG-13. The requirements of INSAG-13 were compared to those regarding the same issue in NS-G-2.4 and DIN EN ISO 9000:2000 ff. The requirements of NS-G-2.4 and DIN EN ISO 9000:2000 ff concerning issues not included in INSAG-13 were not taken into account.
With respect to measurement of safety performance the VGB concept proposes the use of indicators in addition to already existing tools, such as audits, reviews, supervision by managers and the VGB-SBS. The indicators proposed by the VGB concept are intended for medium-term trend monitoring. According to the VGB concept, they are not suitable for early warning in case of decreasing safety performance.

On behalf of BMU, GRS prepared an expert opinion on the VGB concept for the "Optimization of the Safety Management System". In particular, GRS had to check to what extent the VGB concept does fulfill the requirements of the "Fundamentals of Safety Management Systems at NPPs".
Altogether, from the point of view of GRS the VGB concept is too general and vague with regard to essential areas of safety management. E.g. it remains unclear what the safety management system shall comprise and how it shall be structured and implemented. Another point of criticism is the fact that the requirements on the safety management system in the VGB concept do not sufficiently take into account the state of the art. For example, a process-oriented approach is not required in the VGB concept. Therefore, GRS concluded that the VGB concept submitted is not sufficient.

4.2 Integrated Management System of EnBW

Due to an event in summer 2001 in one of its NPPs, EnBW started to develop an indicator-based safety management system and an appropriate process model for its NPPs. During this work it became evident that the development and the implementation of another separated management system in addition to the already existing management systems, such as the quality management system and the environmental management system, is not advisable. Therefore, it was decided to develop an integrated management system (IMS) and to integrate the safety management system in the IMS. In order to ensure nuclear safety, it was decided that nuclear safety has priority over other aspects, particularly business management aspects. I.e. nuclear safety is of highest importance for all safety related tasks.
The IMS comprises the already existing management systems, in particular the quality management system. Among others things one advantage of such an approach is that the use of indicators allows to better fulfill all requirements of plant operation in accordance with standard principles and with a high level of quality and safety.
In order to measure the achievement of the objectives of the processes, in particular of safety-related objectives, EnBW will give priority to measurements with suitable indicators at the level of the safety-relevant process steps. An advantage of such an approach is that the indicators can show deviations from the required performance at an early stage and in a specific way. So, countermeasures can be taken in time. Such indicators can be used as an early warning system in case of a process that is not functioning properly. A prerequisite for this is the definition of expected and limit performance values of the process steps to be monitored. Additionally, more global indicators which are only measuring process results will be applied. These indicators are mainly intended to fulfill the respective information demands of the responsible state authority.
An essential requirement for the development and the implementation of the integrated management system and thus of the safety management system at EnBW was that comparable process models and indicators as well as tools for data collection, processing and presentation should be used at its three sites. Plant-specific modifications should be restricted to a minimum.
The project was started in August 2002. Its first major tasks were the definition of safety-relevant reference processes and the verification of the process model. In the process model, the processes are subdivided into management processes, core processes and support processes. The management processes include all processes, by which strategies, resources as well as the structural and functional organization are determined and the effectiveness of the overall management system is evaluated. The core processes include all processes that are directly required for the production of electric energy. The support processes include all processes, which are not directly involved in power production, but which are important for smooth operation.
At present, the process model of EnBW includes 68 processes. Since work on the process model is currently still going on, the number of processes and their allocation within the process model may still change.

The overall process model of EnBW is shown in figure 2.

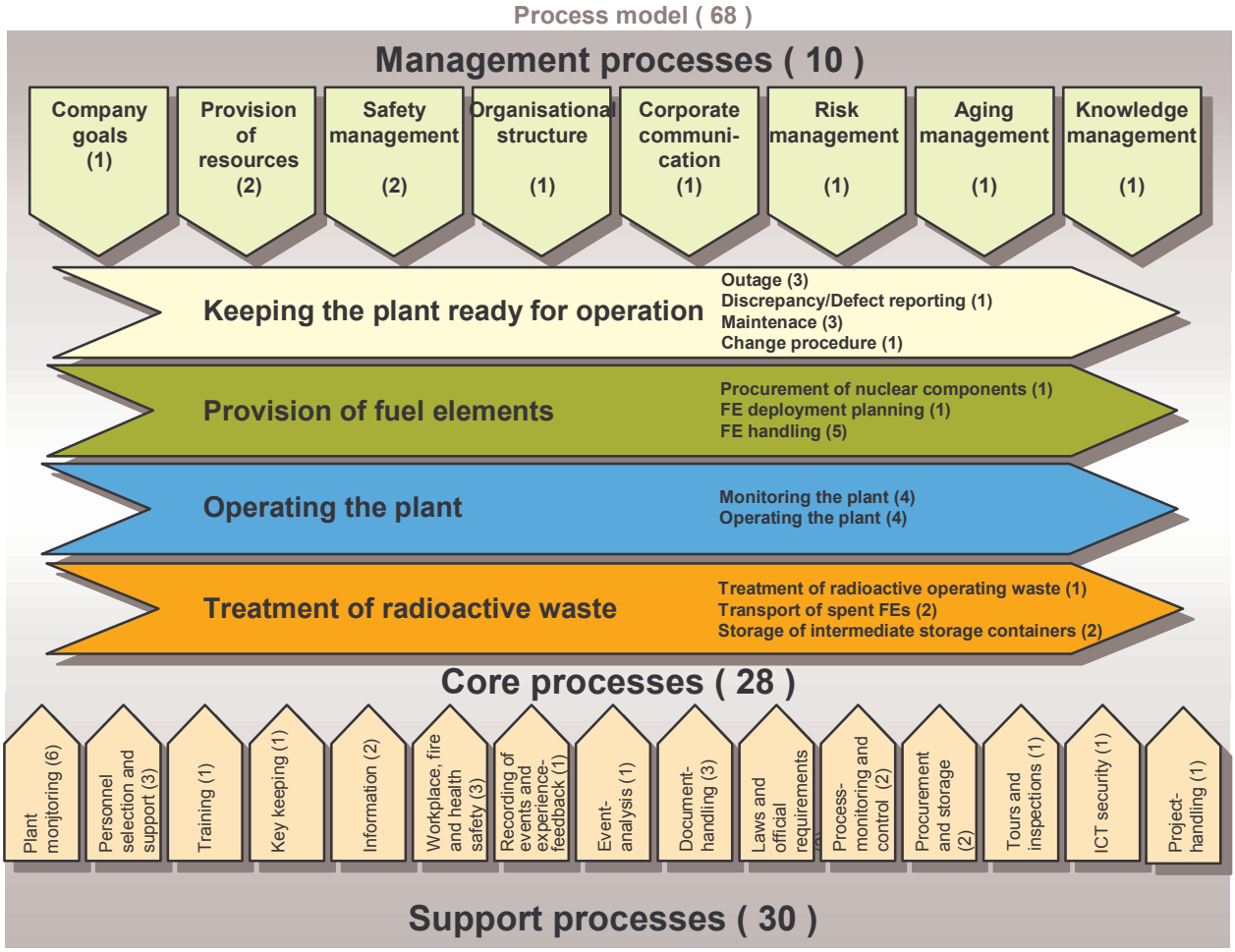

Figure 2: Process model of EnBW

The processes and the procedures required to perform the processes are described in a process manual. The process manual describes, among other things, the strategy finding, the transformation of the strategy in measurable operative objectives and targets as well as the linkage to the safety-related structural and functional organization and thus to the processes that are required for the achievement of strategy and objectives. It describes which processes and procedures are part of the safety management, how the safety management can be monitored concerning its function and effectiveness and how it can be improved continuously.
The development of the reference processes and the associated indicators was finished in September 2004. The adaptation of the reference processes to the plants has started. At the end of October 2004, a basic set of 58 global indicators will be communicated between the state authority and EnBW for the first time.
By the end of the 2004, 35 of the 68 processes shall be implemented at the three sites of EnBW. In parallel to this, a pilot system for collection, processing and presentation of the detailed indicators will be developed. The IMS is scheduled to be operable by the middle of 2005 with the implementation of all plant-specific processes. It shall make a significant contribution to the self-monitoring capability of the EnBW NPPs.

5 EXPERIENCES GAINED AND CONCLUSIONS

At present, there is a controversial discussion in Germany about the question what a safety management system exactly is. On the one hand, there is the opinion that a safety management system should be a separate management system by itself that basically consists of a management process. The other position defines safety management as a comprehensive closed-cycle state of the art management system containing all activities of safety relevance. In addition, the second position considers that it is advisable to implement the safety management system as a part of an integrated management system. The second position corresponds to the understanding of GRS.

In the non nuclear industry, there is a clear trend towards comprehensive management systems that integrate all aspects important for the company such as product quality, occupational safety, environmental protection, costs and so on. One significant reason for this is the experience that an increasing number of separate management systems can only be coordinated with great efforts and will lead to considerable interface problems. At first, EnBW and KKU both tried to develop a separate safety management system. But soon, difficulties as known from other industries started to show up. Therefore, EnBW and KKU decided to introduce an integrated management system including all aspects of safety management. Thus, both are following the development in other industries.

Today, it is common practice in the non nuclear industry to base the integrated management system on the requirements of EN ISO 9000:2000 ff. Furthermore, it is also common practice to base the integrated management system on a process model as proposed in this standard. EnBW and KKU are following this approach, too. They are developing their integrated management system on the basis of EN ISO 9000:2000 ff and a process model.

The revision of the international nuclear rules and regulations on quality management currently carried out by the IAEA takes up the industry's development of the last years with respect to quality management. Thus, the new rules and regulations are aligned with ISO 9001. Aspects specifically related to nuclear safety were added. Part of the revised standard is the idea of an integrated management system and of a process-oriented approach. The "Fundamentals of Safety Management Systems at NPPs" published by BMU are fully taking into account the requirements of the revised IAEA standard on quality management.

The experiences of EnBW and KKU show that the development and implementation of a comprehensive process model is a complex task requiring substantial resources. Further, the experiences show that during development and implementation of the process model a lot of weaknesses as well as potential improvements and optimizations are identified. As a consequence, a need is arising to perform changes of the functional organization and due to this partially also of the existing structural organization. Another need for changes of the structural and functional organization results from the implementation of the process model itself. One example are the so-called process owners who have to be integrated into the existing organization. Such organizational changes must be planned and carried out carefully to prevent any negative impact on safety. Usually, they can only be carried out in a step by step approach.

The experiences mentioned correspond to the experiences in other industries made with the implementation of process models. According to those experiences, full benefit from a process-oriented approach can only be drawn if there is the willingness to adapt the structural and functional organization to the requirements resulting from the process-oriented approach.

An essential requirement for a management system is that the Plan-Do-Check-Act (PDCA) cycle must be closed. Here the question arises whether the demand to close the PDCA cycle only has to be fulfilled at the level of the management system or if the PDCA cycle must also be closed at the process level. One important objective of the closed PDCA cycle is the constant improvement of the processes. Therefore, it is advisable that the PDCA cycle is not only closed at the level of the management system but also for each process.

One problem that emerges from implementation of a process-oriented approach is the coexistence of process documentation and existing plant operating instructions. Due to this,

a great number of issues are regulated in parallel in different plant documents. In the long run, this is neither meaningful nor appropriate. As a consequence, the existing plant operating procedures have to be integrated into the process documentation within an adequate period of time, i.e. the existing plant operating instructions have to be reorganized.
The process-oriented approach represents a comprehensive and systematic approach to carry out all relevant activities at a nuclear power plant. First experiences at EnBW and KKU show that already the implementation of the process model is leading to a large amount of new knowledge. From this, not only the level of safety can be enhanced, but also possibilities for cost savings can be identified. This corresponds to comparable experiences in other industries where the implementation of a process-oriented approach increased product quality and reduced costs.
With the implementation of a closed-cycle management system, the question arises how to measure the achievement of the specified objectives in an adequate manner. EnBW and KKU recognized at a very early stage that the desired early warning function in case of decreasing performance can only be attained if performance measurement and control of the achievement of objectives are carried out in time at the level of processes and sub processes. This means that the respective indicators must be based on the measurement of the results of the processes and sub processes. For this, it is necessary starting at the general objectives to specify in detail for each process and, where required, also sub process all objectives to be achieved. Furthermore, for each individual objective a measurement (indicator) has to be defined that allows a judgement on the achievement of the objective. The experiences gained so far are showing that indicators alone often do not allow a clear judgement whether a process is running smoothly or performs below target levels. In general, it is necessary to evaluate them by means of an engineering judgment. A "traffic light" presentation of indicators seems to be too simplified.
For an effective evaluation, control and improvement of the process results, in principle quantitative indicators are required. The experiences gained so far at EnBW and KKU have shown that such indicators cannot always be determined without difficulty. As a consequence, an appropriate concept for monitoring the process results must be developed, taking already existing tools into consideration, such as audits and reviews. Another experience shows that the quantitative monitoring of process results on the basis of available information and tools may be very challenging. This leads to questions concerning required resources and acceptance. Therefore, it seems to be advisable to consider the requirements of an efficient measurement of process results already during planning of the processes and tools required for their performance. In addition, suitable computer-based tools should be provided.

6 SUMMARY

The awareness of the significance of safety management for the safe operation of NPPs has increased in recent years. This is mainly due to the occurrence of some reportable events which revealed substantial deficiencies in safety management. Therefore, all operators of NPPs as well as the federal and state authorities started activities aiming to implement comprehensive and more effective safety management systems in the NPPs.
An important activity of the authorities was a survey of the current status of safety management systems at German NPPs. The results of this survey showed that comprehensive safety management systems did not exist at German NPPs. As a consequence, BMU and the state authorities demanded the implementation of a comprehensive safety management system at all German NPPs. The German operators agreed to this demand.
In order to ensure a common nationwide level and approach for the implementation and assessment of the safety management systems, fundamentals of safety management systems at NPPs were developed by GRS on the behalf of BMU. These fundamentals were published by BMU. Within the framework of the update of the German nuclear rules and

regulations a set of comprehensive requirements on safety management systems shall become part of the nuclear rules and regulations.
Two plant operators already started very early to develop a comprehensive safety management system based on a process model. Both cases have shown that the implementation of a separate safety management system is not advisable. Therefore, both operators decided to develop an integrated management system and to integrate the safety management system in the integrated management system. This experience corresponds to comparable experiences in other industries. The development of the integrated management systems is at a very advanced state. The integrated management systems are scheduled to be operable in 2005.
It is evident that the implementation of an integrated management system based on a process model is feasible, even though it requires considerable efforts. On the other hand, already the development of the process model is leading to a large amount of new knowledge. Furthermore, development and implementation of a process model reveals a considerable potential for improvements and optimizations concerning safety as well as costs. First experiences with already implemented processes also show that a better planning, control and monitoring of relevant activities in the NPP can be achieved with an integrated process-oriented approach. Thus, it is possible to earlier identify decreasing process performance and to take countermeasures. This leads to an enhancement of performance quality of the relevant activities.