
Goals, progress and difficulties with regard to the development of German nuclear standards on the example of KTA 2000

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ABSTRACT: In Germany, a license may only be granted if the necessary precautions have been taken in the light of the state of the art in science and technology to prevent damage resulting from construction and operation of nuclear power plants.

Primarily, the nuclear regulations serve to specify the vague legal term of the necessary precautions by safety requirements and methods for the verification of their fulfilment.

With KTA 2000, an attempt was made to further develop the existing sublegal nuclear regulations at the level of the KTA Nuclear Safety Standards. In the end, it was not possible to finalise the KTA-2000 project successfully. The reasons and argumentations will be dealt with in the following.

1 INTRODUCTION

The definition of safety of technical facilities is always relative. Since an absolute safety cannot be achieved, the difficulty is to define how safe is safe enough or what the necessary safety is.

In this context, the German legislator defined a criterion. Accordingly, a license may only be granted if the necessary precautions have been taken in the light of the state of the art in science and technology to prevent damage resulting from construction and operation of nuclear power plants. In addition, the licensees are obliged to take the best possible precautions over the entire lifetime of a nuclear power plant. For this purpose, the safety of the nuclear power plants has to be subjected to a continuous optimisation process.

However, safety must be objectively comprehensible. In so far, the vague legal term of necessary precautions has to be specified by safety requirements and methods for the verification of their fulfilment.

This is primarily done by application of the “safety criteria” of the Federal Ministry of the Interior (BMI) which essentially comprise the specified safety objectives to be considered.

These safety objectives are supplemented by safety standards, guidelines and rules which, in addition to general safety requirements, also include the problem-solving technical specifications.

The applicable safety requirements that have to be fulfilled for a nuclear power plant in Germany can be depicted in form of a regulation pyramid (see Fig. 1). At the top of the pyramid, there is the Atomic Energy Act and its ordinances which include the nuclear safety requirements stipulated by law. This is followed by the sublegal regulations. At the top of the sublegal regulations, there are the BMI “safety criteria” of the year 1977. This is followed, according to the degree of specification, by the “incident guidelines” of the year 1983, various promulgations, guidelines and administrative

provisions of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Problem-solving technical specifications are already included in the “Guidelines for PWR“ of the Reactor Safety Commission (RSK) and the recommendations of the RSK and the Commission on Radiological Protection (SSK) that are next in the pyramid. At the bottom of the pyramid, there are the KTA Nuclear Safety Standards and the generally accepted rules of engineering of other institutions.

On the current situation of the sublegal regulations in Germany, the following general statements can be made:

- The sublegal regulations at the upper levels of the regulation pyramid is obsolete, one of the reasons why it is also incomplete.
- At the lower hierarchy levels, updates take place, but the regulations show deficiencies regarding completeness and systematic adaptation to all generations and types of nuclear power plants.

At the end of the nineties, the Nuclear Safety Standards Commission (KTA)¹ decided, on the basis of these findings, to integrate the round 90 KTA Nuclear Safety Standards in a systematic overall approach and to check them with regard to completeness and up-to-dateness. The work was started under the project title “KTA 2000” and conducted until the undertaking was abandoned in the middle of 2003.

2 WHAT WERE THE OBJECTIVES OF KTA 2000?

The main goal of KTA 2000 was to develop safety requirements for design, construction and operation of nuclear power plants in full and in compliance with the state of the art in science and technology. The original intent was also to integrate the safety requirements applicable to the EPR in the German nuclear regulations. Later on, this goal was abandoned. Thus, the tasks within the KTA-2000 project concentrated on the compilation of safety requirements for the assessment of nuclear power plants in operation on the basis of the existing KTA regulations.

The hierarchical structure of the KTA-2000 concept was based on the

- Basic KTA Safety Guidelines,
- Basic KTA Standards, and
- Technical KTA Safety Standards.

In the Basic KTA Safety Guidelines, the safety requirements for a safety concept according to the state of the art in science and technology were to be specified in a systematic approach. Further, the safety requirements were to be oriented towards the applicable basic safety functions and the methods for the verification of fulfilment of the safety functions in the defence-in-depth concept.

The next level in the hierarchy of the planned KTA regulations comprised a total of seven Basic Standards. Here, the requirements for the basic safety functions were summarised in the first four Basic Standards. The subsequent three Basic Standards were to include the generic safety requirements of the defence-in-depth concept.

¹ The KTA consists of the experts of the manufacturers and the operators of nuclear power plants, of authorized experts and state officials in equal shares. Its task is to issue nuclear safety standards for these topics in the area of nuclear technology where a consensus between the experts of the fields represented is apparent due to experience.

Basic Standards were to be developed on the following topics:

- Control of reactivity (No. 1)
- Cooling of fuel elements (No. 2)
- Confinement of radioactive material (No. 3)
- Limitation of radiation exposure (No. 4)
- General technical requirements (No. 5)
- Verification methods (No. 6)
- Administrative personnel requirements (No. 7)

Thus, the goal of the Basic KTA Standards was to compile and to list all safety requirements to be fulfilled by the safety functions, including the necessary methods for verification.

The round 90 Technical KTA Safety Standards at the lower hierarchy levels were to describe further on the technically detailed requirements and procedures of the respective technical field that serve to fulfil the requirement of precautions against damage according to the state of the art in science and technology.

3 WHICH PROGRESS WAS ACHIEVED BY KTA 2000 REGARDING THE DEVELOPMENT OF THE NUCLEAR REGULATIONS

With the KTA-2000 concept it was intended to modernise and restructure the KTA Nuclear Safety Standards without a reduction of safety requirements. The goal was to compile the safety principles, safety requirements and acceptance criteria applicable in Germany and included in the KTA Nuclear Safety Standards completely, orderly and updated in a form that enables the authorities to verify a level of safety that is in compliance with the state of the art in science and technology.

At the same time, KTA 2000 was to be a guideline for the application of the existing nuclear regulations in the safety assessments of nuclear power plants because the existing nuclear regulations reflect the development of technical experiences with design, construction and operation of nuclear power plants over a period of more than 30 years. In addition to the safety principles and the corresponding safety requirements, they also include specifications on special technical designs of safety-relevant components and systems that are in compliance with the state of the art and the technical possibilities at the time of development of the regulations. Due to the update of the nuclear regulations, the scope and the technical specification of the protective measures at the different safety levels of the defence-in-depth concept of the nuclear power plants in operation may therefore be different. According to the regulations, however, it is possible to apply equivalent technical solutions that differ from those specified in the regulations. To take into account the different technical designs of the nuclear power plants constructed over long periods of time, the concept described in KTA 2000 therefore provided to verify, within the frame of safety assessments, the fulfilment of safety functions that are to be applied according to the state of the art in science and technology irrespective of the technical design of the existing nuclear power plants. For this purpose, KTA 2000 was based on an integral approach for safety assessments, consisting on the interaction between the human factor, technology and organisation. By means of KTA 2000, it was intended to compile all of the safety requirements that are characteristic for the basic safety functions of the existing nuclear safety standards of the KTA. In accordance with international recommendations, the safety requirements and verification methods for their fulfilment are consequently oriented towards the defence-in-depth concept with its four levels of safety.

Further, it was intended to fill gaps in the nuclear regulations with KTA 2000. These gaps concern in particular:

- safety requirements on the definitions of Safety Level 4,
- requirements on the methods and performance of safety assessments, in particular with regard to deterministic methods, probabilistic assessments and expert judgements, as well as under consideration of operating experience,
- requirements on the quality and efficiency of administrative personnel requirements.

Moreover, KTA 2000 was to make a contribution to the management of knowledge. As already mentioned, KTA 2000 was to be based on the safety requirements that are independent of the technical designs, which are either explicitly stated in the nuclear regulations or on which these regulations are based upon. In addition, such safety requirements were also to be considered which had not been considered in the nuclear regulations before, but which had proven to be worthwhile by research and development, safety analyses and operating experience. For the work to be conducted on this issue, the KTA established working groups on

1. the compilation of safety requirements included in the sublegal regulations that are independent of design under consideration of the international status,
2. the assignment of these safety requirements to the Basic KTA Standards, and
3. the filling of identified gaps in the regulations.

About 25 GRS experts participated in the work who gained a comprehensive picture of the developments regarding the state of the art of the safety requirements and methods for the verification of their fulfilment in the defence-in-depth safety concept as a result of their activities. With regard to knowledge management, this opportunity of knowledge acquisition and maintenance is also of particular importance because here, as at that time in no other case, technical co-operation of representatives of authorities, expert organisations, manufacturers and utilities took place in the working groups for the maintenance of knowledge.

This also included the detailed verification of the complete compilation of all existing KTA Nuclear Safety Standards by evaluation of all Technical KTA Safety Standards and the related basic material from the development and revision phases of the Technical KTA Safety Standards. In addition, the consistency of the new Basic KTA Standards with one another and in interrelation with the KTA Safety Guidelines was to be checked with documentation of the result.

The regulation pyramid, as envisaged by KTA 2000, comprises the safety requirements that have to be fulfilled in Germany for a safety level that is in compliance with the state of the art in science and technology. With regard to their degree of specification, they are comparable to the IAEA Safety Requirements. The Technical KTA Safety Standards include the requirements for the technical designs of safety functions, which largely correspond to the degree of detail of those included in the IAEA Safety Guides.

It was intended to establish an integral approach on the basis of all existing rules and those under development after their completion which covers safety requirements and safety assessment methods as well as technical design examples for a comprehensive assessment of nuclear power plants in operation according to the state of the art in science and technology.

The contents of the Basic KTA Standards were to be oriented towards the international status and to be based on the safety requirements applicable in Germany. This should consequently be followed by the implementation of safety requirements for the beyond-design-basis area (Safety Level 4) in all Basic Standards, as an extension of the scope of the existing nuclear regulations. The goals of the Basic Standard 6 "Verification methods" and 7 "Administrative personnel requirements" also represent an extension of the scope of regulations in the sublegal nuclear regulations. With regard to the described procedures on safety assessments, Basic Standard 6 is oriented towards the IAEA Safety Guide No. NS-G-1.2, Vienna 2001 "Safety Assessment and Verification for Nuclear Power Plants", Chapter 4 "Safety Analysis". However, Basis Standard 6 also specifies international recommendations on the safety assessment, as e. G. the method of "accepted engineering analysis" described in INSAG-12 (Vienna 1999) "Basic Safety Principles for Nuclear Power Plants 75-INSAG-3 Rev.1".

4 WHICH DIFFICULTIES EMERGED IN THE KTA 2000 PROCESS?

The safety concept on which the existing regulations, and thus the design, are based upon, is largely based on deterministic principles, corroborated by practical experience and data acquired in the course of time.

According to the deterministic safety concept, the safety requirements are based on the definition of design load and load conditions, as well as on the definition of a safety factor. If conditions occur, others than those specified during the design phase, a failure cannot be excluded despite the fulfilment of the safety factors.

The occurrence probability of a failure of components during their lifetime designed this way is not taken into consideration from the outset with this approach. In order to fill this gap, reliability and risk analyses have been performed since the end of the sixties. The probabilistic safety analyses performed for German facilities also demonstrated that an accident risk can be quantified within certain confidence intervals that are beyond the safety limits set by the accident design.

Theoretically, safety margins can be established for such events. In practice, however, there are limits. The problem is the setting of limits and that each limit value on the scale of the occurrence probability could seem to be chosen arbitrarily.

The question is: Is it possible to exclude hazards to an individual for a postulated damage in the case of an occurrence probability of, e. g., $10^{-4}/a$, $10^{-5}/a$ or beginning with $10^{-6}/a$?

Exactly this question has to be answered by the executive. However, this question has not been finally dealt with by now so that an integral assessment criterion for complete nuclear regulations to be established according to the state of the art in science and technology is still missing.

KTA 2000 dealt with these questions and made proposals on the integration of probabilistic safety analyses in the safety assessment, up to the approach of a "risk-informed decision making process".

In the end, KTA 2000 has not met the approval of the executive for this proceeding.

Further, KTA 2000 proposed verification methods for application that are in compliance with the state of the art in science and technology, such as the performance of safety analyses on the basis of best-estimate methods. This implied a reassessment of the conservative approach for safety assessments, thus also of issues as regards contents which are left up to the executive in the end and that are also to be decided upon by it.

The introduction of requirements for a safety management at all levels into the nuclear regulations was not disputed among the persons involved in KTA 2000. The point of issue, however, was the scope and the degree of specification of such requirements.

In the end, it has to be stated that in the past years a further development of the nuclear regulations at the upper hierarchy levels according to the state of the art in science and technology has not been realised.

This, however, is a task that falls within the competence of the executive so that there is no agreed position of the executive on a number of issues that should be included in the nuclear regulations until now.

With the goal to achieve completeness and up-to-dateness of the nuclear regulations, KTA 2000 also affected contents of competence fields which could not be dealt within the period scheduled or which exclusively fall within the competence of the executive.

For this reason, the work within the framework of KTA 2000 was stopped by the BMU. It was of special importance for KTA 2000 that almost exactly with the start of the work on KTA 2000 the political boundary conditions basically changed, resulting in considerable consequences for the publicly supported consensus on the operation of nuclear power plants. With the decision on the termination of the use of nuclear energy for electricity production, the bases for the development of nuclear regulations, which were principally developed on the basis of the consensus of all parties involved as regards contents, also have changed.

The guidelines and principles for the update of nuclear regulations now have to be developed at the executive level and implemented correspondingly.

Recently, however, work on completion and update of the sublegal regulations at the higher hierarchy levels have been started by the BMU.

Fig. 1: Survey of nuclear regulations in Germany

