EUROPEAN UTILITY REQUIREMENTS
FOR LWR NUCLEAR POWER PLANTS

VOLUME 1

MAIN POLICIES AND OBJECTIVES

CHAPTER 2

EUR POLICIES

Revision E

December, 2016

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List and status of the sections of the Chapter 1.2 Revision E, December 2016

1.2 EUR POLICIES

Revision E *December, 2016*

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1.2 1 FOREWORD E-00

Nuclear Energy is an important source of low-carbon base-load electricity in Europe. As such, retaining it as a significant contributor to the energy mix will assist Europe to reach its targets for reduction in greenhouse gas emissions. To achieve that end, the nuclear industry needs to ensure it has a very high level of safety and also maintains its competitiveness. The Fukushima accident led to a reinforcement of safety goals in Europe. Harmonisation of requirements, such as those described in this EUR Document provides an essential contribution to the fulfilment of these goals for new nuclear plants.

1.2 2 INTRODUCTION E-00

In recent years, EUR Utilities have faced a changing environment within the nuclear industry. Some of the changes are more favourable to nuclear, others are less so: the following changes in this environment have come under consideration during the development of this Revision E of the EUR Document:

- An aging fleet of nuclear power plants which are in transition to long term operation;
- An increasing number of subsidised intermittent renewable sources (e.g. wind and solar) that affects not only the electricity market but also the reliability of electricity supply system;
- A huge pressure globally to reduce carbon emissions;
- Economic constraints due to the low wholesale price of electricity in Europe and other hidden costs (including taxes);
- Public concerns regarding the acceptability of nuclear energy after the Fukushima accident; and
- A general trend for greater international co-operation in nuclear safety, for more transparency in nuclear operations and for increased levels of regulation on both proposed new plants and existing plants.

The EUR Utilities believe that nuclear energy combined with a mix of renewable energy sources remains the optimal direction to ensure that sustainable development goals are met (i.e. to reduce greenhouse gas emissions, to provide affordable prices for electricity and to ensure security of supply).

However, the path to create this future has to be supported by an unambiguous demonstration to the citizens of Europe that the industry is safe, presents no harm to neighbouring states under any foreseeable circumstance and which respects the environment. The industry cannot succeed without being competitive as a means of electricity production compared to the alternatives, where the economics rely on the achievement of high operational performance targets and reliable contributions to the electricity grid operations. This must be achieved by paying particular attention to Human Performance at the design stage.

To reflect the above beliefs, the EUR Utilities have developed five specific policies: Safety, Environmental Protection, Economics, Operational Performance and Human Factors.

These policies summarise the main routes which EUR members believe need to be followed to be successful to achieve safety and competitiveness and they should be taken into consideration when specifying a new power plant to be built in any European state. They provide the foundation of Revision E of the EUR Document

1.2 3 SAFETY POLICY E-00

Operating experience which has been collected, collated and analysed over the past 50 years shows that Nuclear Safety is a changing scene that is evolving constantly throughout the industry. The body of knowledge is regularly updated to take into account experience from various sources, including operations, regulation, research, design and technology development. For the European Utilities, the EUR Document embodies the learning as this experience is gathered continuously and includes the most recent feedback on safety performance from across the worldwide nuclear industry.

The lessons learnt from the Fukushima accident have been captured from analysis undertaken across the world and the most up-to-date standards are derived from it (including IAEA's Safety of Nuclear Power Plants: Design (SSR 2/1 Rev. 1) and the Safety Objectives for New Nuclear Power Plants from WENRA). These modern standards have been considered and incorporated into the EUR Document.

In addition the EUR Document benefits from the application of the European Utilities vision and expectations about what constitutes a safe and economic design for future new plants in Europe. The Utilities maintain a constant interaction with both designers and regulators, as well as participating in benchmarking exercises which are organised to share experience on a regular basis. Our vision and expectations are also aimed at creating an affordable nuclear energy market in Europe through the provision of harmonised requirements which will lead to new plant designs with standardised features.

The technical implications of this continuous application of the European Utilities experience are presented in the EUR Document which defines the following safety objectives and positions:

- A framework for the Defence-in-Depth (DiD) concept which draws together at the same level (Level 3) both Design Basis Accidents and Complex Sequences. From a design perspective the division of this level into two sub-levels (Levels 3a and 3b) permits the definition of engineering design requirements consistent with both groups of event. Such a framework allows a clear identification, within the full scope of Accident Conditions, of conditions leading to a core damage (which are allocated to Level 4). EUR radiological targets are presented accordingly and provide designers with a more detailed approach within the application of the DiD concept for the plant design, specifically setting expectations for containment performance. The Criteria for Limited Impact (CLI) have now been set so that any accident which could lead to even a low level impact on the local population, as well as events of a more serious nature (e.g. involving core damage), requires only a limited emergency response in terms of the area affected and the time for which any restrictions must remain in place;
- The full scope of events which need to be taken into account in the design of new plants. The "practical elimination" approach introduced in the EUR Document permits an identification and justification, from all potential events which could threaten plant safety, of those which could lead to large or early releases. These must be eliminated by practical design provisions. Those events that cannot be "practically eliminated" are retained as part of the general basis for the design of systems, structures and components;
- A strict and logical process to identify and classify all plant structures, systems and components required to provide the safety demonstration. The consideration of all events which have the potential to threaten plant safety are considered in a Safety Classification approach which addresses all these systems, structures and components and which takes into account the most recent international experience and engineering judgments which need to be applied. The outcome of this classification approach supports the definition of the engineering codes and standards to be applied in the design;
- A comprehensive consideration of conditions induced by hazards, especially those of external origin. For such external hazards, conditions taken into account at the standard design level (i.e. design basis external hazards - DBEH) are complemented by conditions which are representative of rare and severe external hazards (RSEH). Resilience of structures, systems and components required to maintain the plant in a safe condition after RSEH will have to be demonstrated at a higher level of severity;
- A safe response of the plant to man-made hazards, especially those related to security issues. Specific requirements are included the EUR Document which takes account of international experience on nuclear security. These requirements are aimed at ensuring comprehensive protection of new plants against the full range of potential threats;

- A clear approach to plant and site autonomy. Extreme situations are the main focus of the autonomy objectives, especially in response to long term loss of electrical power supplies or loss of the ultimate heat sink. Values of 72 hours and 7 days are proposed as the basic autonomy requirements for the design of structures, systems and components required in such extreme situations. This approach relies principally on fixed equipment which is permanently installed on the plant or within the site boundary. Potential credit can, however, be taken for the use of non-permanent equipment in some specific situations, so long as this equipment is identified beforehand and is designed to be stored and used in accordance with appropriate rules; and
- A comprehensive organisation, supported by appropriate arrangements and facilities, for the management of emergency situations, in the unlikely event that such situations occur on the site. In Revision E, on-site and off-site means which are required to mitigate such situations have to be identified and organised into several independent emergency response facilities. The role of each facility is defined and usually would include an additional control room, together with technical support and response centres.

The ultimate objective of Revision E is to provide a strong basis for a robust and balanced new plant design. It takes into account the experience of all European Nuclear Utilities and is informed by guidance, regulations and standards which have been issued both internationally and nationally: Worldwide (e.g. IAEA), European (e.g. WENRA and ENSREG), National Safety Regulatory Authorities in Europe and outside Europe.

EUR requirements are presented in such a way as to remain neutral with respect to the specific nuclear technology to be deployed. It is open to the demonstration of how innovative technologies and advanced technical solutions can be used in modern nuclear power plants. Within Revision E, major safety requirements are identified in Chapter 2.1 which then cascade into other chapters for detailed implementation. The complete set of chapters provides a set of requirements that make Revision E an essential tool to the European nuclear utilities community in support of the development, design, licensing and construction of new nuclear power plants in Europe.

1.2 4 ECONOMICS POLICY E-00

EUR considers that a prime requisite for investing in new Light Water Reactors is to make sure that the generation costs - including construction, fuel, operation, maintenance and dismantling - will be low, as far as is reasonably practicable, while respecting the safety objectives and recognising the potential impact of the plant on the public, workers and the environment.

Implementing this general policy for a new Generation III plant must result in a balanced design which will provide a high level of competitiveness compared to other competing low-carbon electricity generation technologies and will also secure the stakeholders investment with a high degree of confidence, through the profitability of the plant over its lifetime.

It should be recognised that currently the EUR Document addresses designs of LWR in the medium-large and large size ranges, from 600MW up to 1800MW nominal gross power output and a minimum design lifetime of 60 years which provides for their economic attractiveness and compatibility with European transmission grid conditions.

The EUR Document recommends that the generation cost is assessed on the basis of a levelised cost of electricity (LCOE) methodology, considered as an important tool to be used both for optimisation at the design stage and for comparison between different energy generating technologies. No value is given in the EUR Document for a generation cost target since it varies with country specific conditions. However, the document specifies the information which needs to be provided by the designer in order to evaluate the cost of construction, fuel, operating, maintenance and dismantling.

Further to this objective, and because it is the major contributor to the LCOE, construction cost control is considered by EUR as the most important tool to assure the achievement of the economic objectives. For this reason, the EUR Document specifies requirements on simplification, standardisation of design features and constructability, which all aim at contributing to cost-reduction during the construction phase and at ensuring that the construction schedule will be met within the target cost. EUR considers that avoiding complexity must be a key driver for the overall design of a cost-effective plant, and that it will contribute both to improve the safety of the plant and facilitate the acceptance of the design by the licensing authorities.

The EUR Document promotes the harmonisation of requirements which will lead to standardisation of design features in order to facilitate the licensing of the plant in the different countries of the EUR partners without the need for significant changes to meet differences in national licensing requirements. Moreover, taking into account the benefit of greatly simplified systems and advanced construction methods, EUR also emphasises the use of structures, systems, and components with the same characteristics and proven materials which have been successfully applied in existing LWRs or similar operating environments.

The EUR intent is also to use as much experience feedback, gained during previous projects on a defined reference plant, or similar plants in operation, as possible in the design process. The extensive and systematic use of this experience feedback helps the designer to avoid problems affecting construction, operation and maintenance, and thus minimises the risk for the plant owner and investor.

1.2 5 ENVIRONMENTAL PROTECTION POLICY E-00

The basis of this EUR policy is that all the different phases of the life cycle of a nuclear plant - construction, operation and dismantling - minimise the impact on the public, workers and the environment as a priority.
To implement the policy, the EUR Document defines a set of specific objectives to limit both the generation of solid and liquid radioactive wastes and the routine releases of radionuclides to the surrounding environment in liquid and gaseous forms to levels as low as reasonably achievable (i.e. the ALARA approach). The EUR also recognises the importance of ensuring sufficient flexibility in the design process which utilises best available techniques to ensure the protection of humans and the environment and allows compliance with the specific regulatory limits of each country. The use of hazardous and toxic chemicals is also limited to minimise the risk to the environment by the use of appropriate design, engineered controls, monitoring and written arrangements.
With regard to radiological wastes, it is an EUR objective to minimise waste generated during the lifetime of the plant (via both concentration and volume reduction) through the application of the best available techniques. In the EUR Document, this objective results in a set of requirements which lead to minimisation through both concentration and volume reduction of solid and liquid wastes.
Consideration of radiation protection at the design stage is implemented through requirements established from current plant experience in Europe. EUR dose targets for radiation exposure of the public and workers during normal operation of the plant, defined in accordance with international standards, such as ICRP, have to be considered by the plant designer as acceptance criteria when designing the buildings, systems and materials or defining operation, maintenance and decommissioning processes for the plant. For normal operation of a new plant, this objective is reflected in the EUR Document by setting a requirement which optimises public exposure through a dose constraint based on the latest ICRP recommendations.

1.2 6 OPERATIONAL PERFORMANCE POLICY E-00

EUR considers that setting challenging availability and capability targets for new Light Water Reactors is an efficient way to achieve the objective of competitiveness and to ensure an acceptable return on investment. Optimised availability and capability factors are also considered as a major indicator of plant safety since a plant running well is a plant which is less likely to experience incidents from which accident conditions might develop.

Unplanned or unnecessarily long downtimes and outages have a negative impact on a nuclear power plant's performance. Optimisation of maintenance concepts, improved component cleaning and inspection methods, as well as troubleshooting following inspection findings support reductions in outage length.
Implementing this policy for a new Generation III plant must result in meeting the general objective for an annual Design Availability Factor greater than 90% over a reference period of 20 years based on a fuel cycle which is equal to, or longer than, 12 months.
To address this objective, the EUR Document defines availability targets, such as the maximum duration for planned outages (from 14 to 36 days depending on the type of outage), as well as the manoeuvring capability of the plant which results in the optimisation of the duration of the cool-down and start-up phases such as, for instance, no more than 24hr. from hot shutdown to synchronisation to the grid. Reliability studies shall also be undertaken to ensure a low level of unplanned outages and reach the EUR objectives such as an annual forced unavailability factor lower on average than 1.5% over a 20-year reference period.
The design of the plant is also expected to permit the performance of both scheduled and unscheduled load following operations during 90% of the whole fuel cycle, and the flexibility for extending operation beyond the natural fuel cycle length. It is also expected that fuel-related limitations on plant manoeuvring that can result in reduced availability and capability factor will be minimised.

1.2 7 HUMAN FACTORS POLICY E-00

EUR recognises the importance of a systematic consideration of human factors and the human-machine interface (HMI) in the design process at an early stage of design development, which should continue throughout the entire process. Human factors principles which are consistently applied throughout the design process for each operating or maintenance work space will help reduce operation and maintenance errors during all plant operating modes.
To implement this policy, it is essential that the design process integrates all technical disciplines along with experienced operating personnel in the early phases of the design in order to establish the performance objectives and operating requirements for the new plant. EUR requires that the design process takes into account human-machine interface issues which have been identified in existing nuclear plants and provides satisfactory solutions to them in new plants. EUR considers that a well-designed human-machine interface is an effective means to reduce errors and facilitate correct diagnosis and subsequent human actions.
In the interests of safety, EUR requires that the working areas and environment for workers are designed according to ergonomic principles and promote successful operator actions in the light of the time available, the expected physical environment and the psychological pressure. The use of modern technology for designing the main control room is required to ensure operators are provided with adequate and understandable information in order to assess the current plant status in all plant states to enable them to operate the plant safely. The design of the main control room must be based on a compact and ergonomic concept so as to make all alarms, displays and procedures easily accessible to the operators.
It is also part of the EUR policy that suitable and sufficient training materials are available for initial and periodic training and qualification of the different plant staff, including control room operators. To fulfil this objective, EUR considers that it is a Plant Designer responsibility to provide the necessary data and documentation which will allow the construction of simulators, including a full scope training simulator, and later for design review, testing of automation and development of operating and maintenance procedures.
In addition to the potential benefits of considering human factors principles in the early design of the plant, EUR also considers that the reliable performance of the correct human actions have to be considered as a major input in the safety demonstration of the plant. This objective results in a set of EUR requirements that lead the designer to consider, for instance, human reliability in the Probabilistic Safety Analysis (PSA) as well as a 30 minute grace period for operator actions in the main control room and 60 minutes on the remainder of the plant.