International Application of Nuclear Safety Codes
IAEA Guideline Review

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Idaho National Laboratory

Reports Common User Considerations (CUC) by Developing Countries for Future Nuclear Energy Systems: Report of Stage 1, No. NP-T-2.1

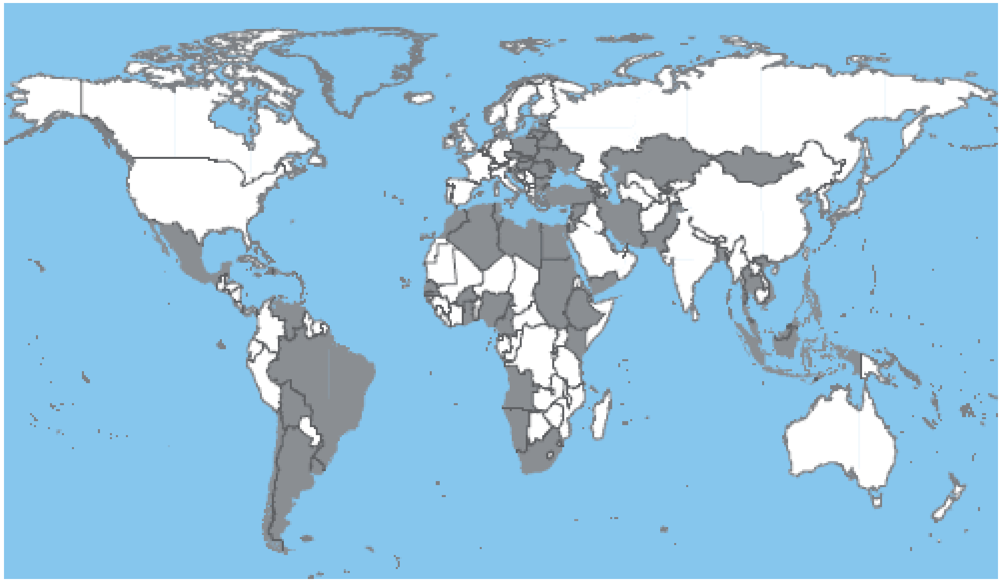

FIG. 1. The 54 countries addressed by the CUC (technology user countries).

Desired Technology for new countries

(1) Economics and financing;
(2) Infrastructure and implementation;
(3) Nuclear Safety; environment;
(4) Resources and waste management;
(5) Proliferation resistance;
(6) Physical protection;
(7) Technical requirements.

Potential New Nuclear Applications

Europe: Italy, Albania, Serbia, Croatia, Portugal, Norway, Poland, Belarus, Estonia, Latvia, Turkey.
Middle East: Iran, UAE, Saudi Arabia, Qatar, Kuwait, Yemen, Israel, Syria, Jordon, Egypt, Tunisia, Libya, Algeria, Morocco, Sudan.
Africa: Nigeria, Ghana, Senegal, Kenya, Uganda, Namibia.
South America: Chile, Ecuador, Venezuela
Central Asia: Azerbaijan, Georgia, Kazakhstan, Mongolia, Bangladesh, Sri Lanka
SE Asia: Indonesia, Philippines, Vietnam, Thailand, Malaysia, Singapore, Australia, New Zealand, North Korea
Very little actual growth in nuclear power usage, long term trends indicate significant increases in electrical use. Current power primarily gas and oil with some countries using coal.

Current Status

Building reactors: UAE
Procurement: Lithuania, Turkey, Belarus.
Plans and infrastructure: Vietnam, Jordan, Poland, Bangladesh,Thailand, Indonesia, Egypt, Kazakhstan, Saudi Arabia, Chile
Planning: Israel, Nigeria, Malaysia, Morocco, Kuwait.
Policy Questions: Namibia, Kenya, Mongolia, Philippines, Singapore, Albania, Serbia, Croatia, Estonia & Latvia, Libya, Algeria, Azerbaijan, Sri Lanka, Tunisia, Syria, Qatar, Sudan, Venezuela
Stalled: Italy

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Project Stages

- **Pre-project phase 1** (1-3 years) commitment to a nuclear power program, resulting in set up of a Nuclear Power Program Implementing Organisation (NEPIO). This deals with the program, not the particular projects after phase 2.
- **Project decision-making phase 2** (3-7 years) involving preparatory work after the decision is made and up to inviting bids, with the regulatory body being established. In phase 2 the government role progressively gives way to that of the regulatory body and the owner-operator.
- **Construction phase 3** (7-10 years) with regulatory body operational, up to commissioning and operation.

Milestones in the development of national infrastructure for nuclear power (2007), and *Evaluation of the national nuclear infrastructure development status* (2008). These are being updated with a view to new editions about 2013.

Nuclear Power Today

In December 2011 there were 435 nuclear power reactors

New reactors on grid: Ling Ao-4, Qinshan-2-4, China Experimental Fast Reactor (CEFR); Kaiga-4; Bushehr-1; Chasnupp-2; Kalinin-4

Construction Start: Chasnupp-3,4; Rajasthan-7,8

Shut down: Fukushima Daiichi 1-4, Biblis A,B, Brunsbüttel, Isar-I, Krümmel, Neckarwestheim-1, Philippsburg-1, Unterweser; Oldbury A2

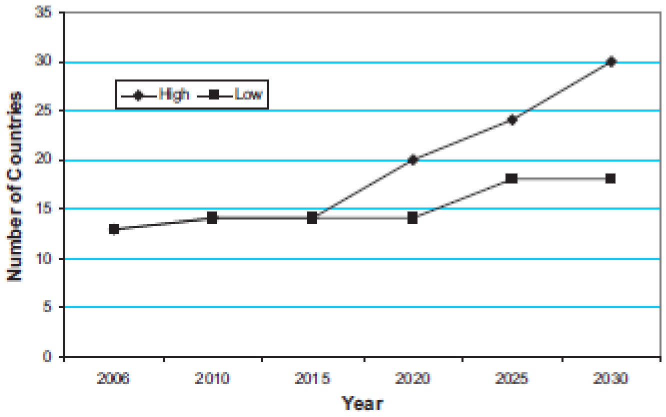

FIG. 21. Projection of the number countries with nuclear power plants among the user countries.

Nuclear Technology Transfer to New Operators

They regard technology transfer from suppliers (including the supplier countries) as a key to increasing such capabilities. Among technology transfer items the experts are particularly interested in codes and methods on design analysis of the system and associated know-how of their usage for independent checking. They would also be interested in obtaining specifications and design drawings to develop independent capability for maintenance and upgrading of the plant, and know-how on system design, construction and component manufacturing for industry buildup.

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SAFETY OBJECTIVES AND CONCEPTS

- **General Nuclear Safety Objective:** To protect individuals, society and the environment from harm by establishing and maintaining in nuclear installations effective defenses against radiological hazards*.*
- **Radiation Protection Objective:** To ensure that in all operational states radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable, and to ensure mitigation of the radiological consequences of any accidents.
- **Technical Safety Objective:** *To take all reasonably practicable measures to prevent accidents in nuclear installations and to mitigate their consequences should they occur; to ensure with a high level of confidence that, for all possible accidents taken into account in the design of the installation, including those of very low probability, any radiological consequences would be minor and below prescribed limits; and to ensure that the likelihood of accidents with serious radiological consequences is extremely low.*

Safety of Nuclear Power Plants: Design
REQUIREMENTS No. NS-R-1

RESPONSIBILITIES IN MANAGEMENT

3.1. The operating organization has overall responsibility for safety. However, all organizations engaged in activities important to safety have a responsibility to ensure that safety matters are given the highest priority. The design organization shall ensure that the installation is designed to meet the requirements of the operating organization, including any standardized utility requirements; that it takes account of the current state of the art for safety

Thus, the design organization shall:

(1) have a clear division of responsibilities with corresponding lines of authority and communication;

(2) ensure that it has sufficient technically qualified and appropriately trained staff at all levels;

(3) establish clear interfaces between the groups engaged in different parts of the design, and between designers, utilities, suppliers, constructors and contractors as appropriate;

(4) develop and strictly adhere to sound procedures;

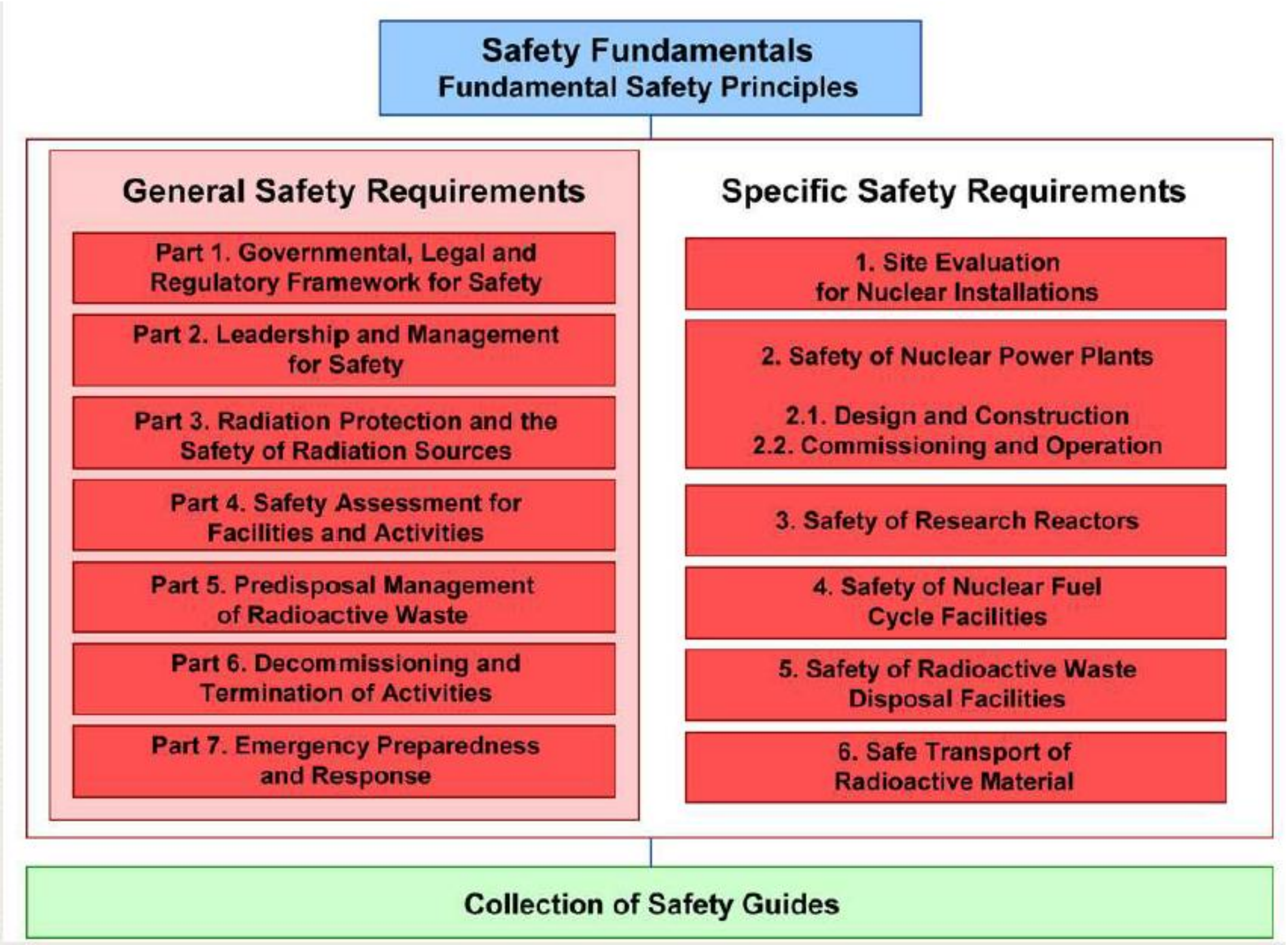
(5) review, monitor and audit all safety related design matters on a regular basis;

(6) ensure that a safety culture is maintained.

Safety of Nuclear Power Plants: Design REQUIREMENTS No. NS-R-1

IAEA Safety Standards for Regulatory Activities,

Regulatory Activities Section of Nuclear Installation Safety Presentation



SAFETY ASSESSMENT

3.10. A comprehensive safety assessment shall be carried out to confirm that the design as delivered for fabrication, as for construction and as built meets the safety requirements set out at the beginning of the design process.

3.11. The safety assessment shall be part of the design process, with iteration between the design and confirmatory analytical activities, and increasing in the scope and level of detail as the design program progresses.

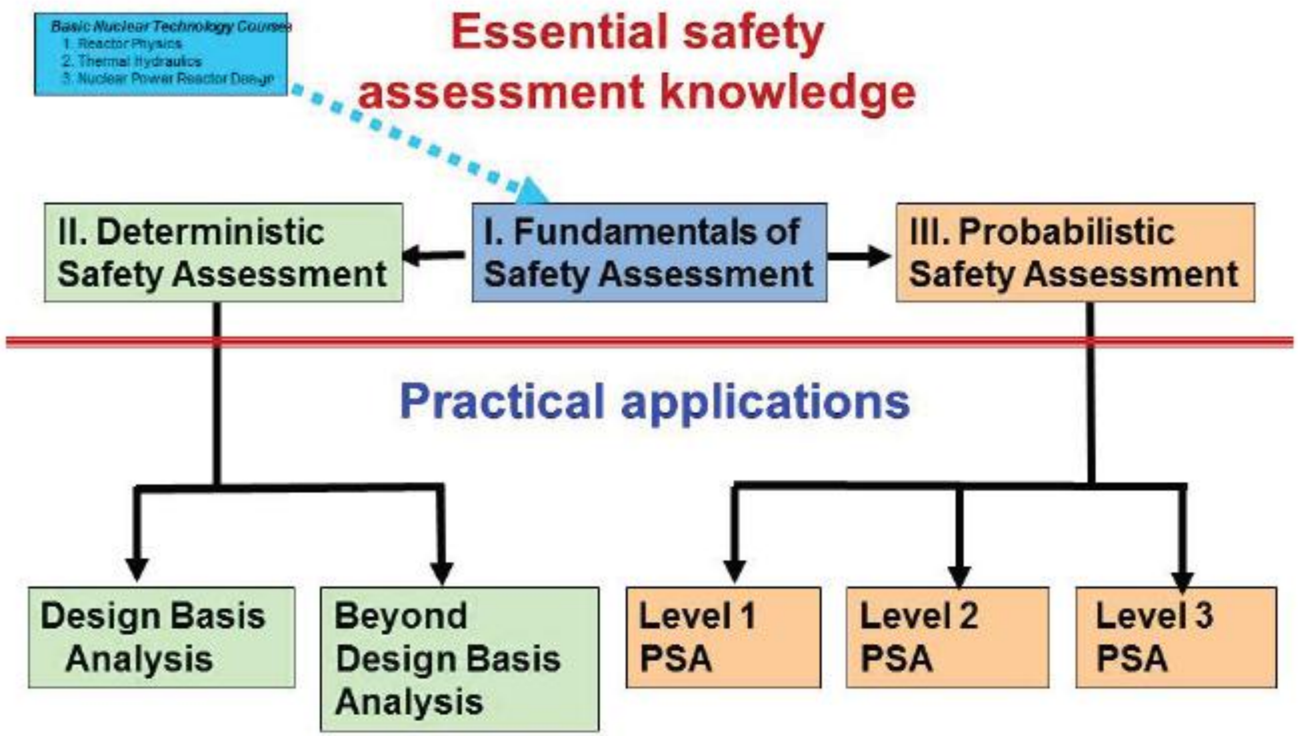
3.12. The basis for the safety assessment shall be data derived from the safety analysis, previous operational experience, results of supporting research and proven engineering practice.

SAFETY ANALYSIS

5.69. A safety analysis of the plant design shall be conducted in which methods of both deterministic and probabilistic analysis shall be applied. On the basis of this analysis, the design basis for items important to safety shall be established and confirmed.

5.70. The computer programs, analytical methods and plant models used in the safety analysis shall be verified and validated, and adequate consideration shall be given to uncertainties and shall be consistent with the current or ‘as built’ state.

SAET Curriculum Structure



Deterministic approach

- 5.71. The deterministic safety analysis shall include the following:

  (1) confirmation that operational limits and conditions are in compliance with the assumptions and intent of the design for normal operation of the plant;

  (2) characterization of the PIEs (see Appendix I) that are appropriate for the design and site of the plant;

  (3) analysis and evaluation of event sequences that result from PIEs;

  (4) comparison of the results of the analysis with radiological acceptance criteria and design limits;

  (5) establishment and confirmation of the design basis; and

  (6) demonstration that the management of anticipated operational occurrences and design basis accidents is possible by automatic response of safety systems in combination with prescribed actions of the operator.

- 5.72. The applicability of the analytical assumptions, methods and degree of conservatism used shall be verified. The safety analysis of the plant design shall be updated with regard to significant changes in plant configuration, operational experience, and advances in technical knowledge and understanding of physical phenomena

REACTOR COOLANT SYSTEM

Design of the reactor coolant system

6.21. The reactor coolant system, its associated auxiliary systems, and the control and protection systems shall be designed with sufficient margin to ensure that the design conditions of the reactor coolant pressure boundary are not exceeded in operational states. Provision shall be made to ensure that the operation of pressure relief devices, even in design basis accidents, will not lead to unacceptable releases of radioactive material from the plant. The reactor coolant pressure boundary shall be equipped with adequate isolation devices to limit any loss of radioactive fluid.

Removal of residual heat from the core

6.33. Means for removing residual heat shall be provided. Their safety function shall be to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified fuel design limits and the design basis limits of the reactor coolant pressure boundary are not exceeded.

6.34. Interconnections and isolation capabilities and other appropriate design features (such as leak detection) shall be provided to fulfill the requirements of paragraph 6.33 with sufficient reliability, on the assumptions of a single failure and the loss of off-site power, and with the incorporation of suitable redundancy, diversity and independence.

Emergency core cooling

- 6.35. Core cooling shall be provided in the event of a loss of coolant accident so as to minimize fuel damage and limit the escape of fission products from the fuel. The cooling provided shall ensure that:

  (1) the limiting parameters for the cladding or fuel integrity (such as temperature) will not exceed the acceptable value for design basis accidents (for applicable reactor designs);
  (2) possible chemical reactions are limited to an allowable level;
  (3) the alterations in the fuel and internal structural alterations will not significantly reduce the effectiveness of the means of emergency core cooling; and
  (4) the cooling of the core will be ensured for a sufficient time.

Heat transfer to an ultimate heat sink

- 6.39. Systems shall be provided to transfer residual heat from structures, systems and components important to safety to an ultimate heat sink. This function shall be carried out at very high levels of reliability in operational states and in design basis accidents.

Design of the containment system

- 6.43. A containment system shall be provided in order to ensure that any release of radioactive materials to the environment in a design basis accident would be below prescribed limits.

REQUIREMENTS FOR PLANT DESIGN

SAFETY CLASSIFICATION

5.1. All structures, systems and components, including software for instrumentation and control (I&C), that are items important to safety shall be first identified and then classified on the basis of their function and significance with regard to safety. They shall be designed, constructed and maintained such that their quality and reliability is commensurate with this classification.

5.2. The method for classifying the safety significance of a structure, system or component shall primarily be based on deterministic methods, complemented where appropriate by probabilistic methods and engineering judgement, with account taken of factors such as:

(1) the safety function(s) to be performed by the item;
(2) the consequences of failure to perform its function;
(3) the probability that the item will be called upon to perform a safety function;
(4) the time following a PIE at which, or the period throughout which, it will be called upon to operate.

5.3. Appropriately designed interfaces shall be provided between structures, systems and components of different classes to ensure that any failure in a system classified in a lower class will not propagate to a system classified in a higher class.