Radiation and Nuclear Safety Authority

96/0002/2016

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Guide YVL A.7, Probabilistic risk assessment and risk management of a nuclear power plant

1 Scope of application

Guide YVL A.7 shall be applied to an applicant for and a holder of a Government decision-in-principle under the Nuclear Energy Act, an applicant for and a holder of a construction licence for a nuclear power plant and an applicant for and a holder of an operating licence for a nuclear power plant.

2 Justifications of the requirements

2.1 Nuclear Energy Decree (161/1988)

When applying for a construction licence, the applicant shall submit to the Radiation and Nuclear Safety Authority a probabilistic risk assessment of the design stage under section 35 of the Nuclear Energy Decree, and when applying for an operating licence, a probabilistic risk assessment under section 36 of the Nuclear Energy Decree.

Chapter 3 a: Limitation of radiation exposure and releases of radioactive substances

Section 22 b:

The limit for the annual dose of a member of the public, arising from the normal operation of a nuclear power plant or another type of nuclear facility equipped with a nuclear reactor, shall be 0.1 millisievert. The limit for the annual dose of a member of the public, arising from the planned decommissioning of a nuclear power plant or another type of nuclear facility equipped with a nuclear reactor, shall be 0.01 millisievert.

The limit for the annual dose of an individual in the population, arising as the result of an anticipated operational occurrence, shall be 0.1 millisievert.

The limit for the annual dose of an individual in the population shall be 1 millisievert for class 1 postulated accidents, 5 millisievert for class 2 postulated accidents and 20 millisievert for a design extension condition.

The release of radioactive substances caused by a severe reactor accident or a severe accident at a nuclear power plant may not result in the need for large-scale population protection measures or prolonged restrictions on the use of large areas of land and water.

In order to limit the long term effects, the limit for atmospheric releases of cesium-137 is 100 terabecquerel. The possibility of exceeding the set limit shall be extremely small.

The possibility of a release in the early stages of an accident requiring measures to protect members of the public shall be extremely small.

2.2 Justifications of the requirements by topic

Requirement 301: The requirements concerning the design, construction and use of nuclear power plants emphasise risk informed approach. It is therefore necessary that this method is also included in the licensee's management system, which shall describe the principles of risk informed decision-making.

Requirements 305–306: A result calculated with a point value cannot be used in this context. Uncertainties shall be taken into account in frequencies, probabilities and release fractions (release fractions, migration, retention).

Requirement 306, item b: In this context, early means that there is no time to implement the warning and protective measures prior to the release. An exact number of hours has not been defined, but warning and protection are typically estimated to take approximately four hours after the rescue department receives information on the need to take shelter. (Guide VAL 1.) The objective is that protective measures are not needed in a situation in which there would practically be no time to implement them.

The failure and loss of the containment function cover the containment failure, bypass sequences and isolation failure. The reference value, therefore, is the plant's core damage frequency, not, for example, a limit of 10^{-5}/year. The requirement cannot be met with just low initiating event frequencies, but the containment function must be reliable.

The requirement for applying PRA applies to all currently used and spent nuclear fuel regardless of whether the nuclear fuel is in a reactor, temporarily stored at a plant unit or waiting for final disposal at an interim spent fuel storage.

Requirement 309: The requirements concerning the design and construction of nuclear power plants emphasise the risk informed layout planning and system design in order to take into account internal and external hazards and associated extreme phenomena as early as possible in the design phase of nuclear power plants.

Requirement 310: The requirements concerning the design and construction of nuclear power plants emphasise the risk informed layout planning and system design in order to take into account internal and external hazards as early as possible. This aims to prevent, among other things, the occurrence of common cause initiators due to exceeding the design basis, for example, during extreme weather phenomena. Long-term accidents (Fukushima) have also been considered in the requirement.

Requirement 315: Submitting PRA updates, the PRA computer model and updated results to STUK regularly is necessary for regulatory oversight of plant design and construction.

Requirement 323: PRA has not always been used to support the definition of deterministic event categories. The definition of PRA initiating event frequencies is based on the operational event data of nuclear power plants. The available

operational event data covers a total of 15,000 operating years of nuclear power plants.

Requirement 324: Formerly, the event sequences of severe accidents for which radiation effect analyses were prepared were selected deterministically. There is so much experience of using PRA (PRA level 2) that PRA can be utilised in determining the most important event sequences of severe accidents for emergency response arrangements.

Requirement 325: The requirement is related to utilising PRA in risk informed safety management during all phases of the life cycle of the plant. The objective is to optimise the commissioning test programmes in terms of the benefit and risk of pre-operational testing.

Requirement 327: If the system modification is not significant, a qualitative analysis or expert judgment shall suffice. In significant system modifications, PRA analyses can be used, for example, in assessing different options.

Requirements 335– 336: The requirements are applicable for the time period after ending the power operation of the nuclear power plant, when there is still fuel at the plant or at other interim spent fuel storages. The PRA shall also cover the risks due to fuel damage and radioactive releases when decommissioning a nuclear power plant. Provisions for decommissioning shall be planned as early as in the design phase of plants.

Requirement 403: The requirement specifies the design-phase seismic PRA. In the first place, a logical model shall be developed and expert judgment shall be used for data estimates. If, concerning the seismic PRA, the development of the model is not considered to be reasonable because of the lack of design data, the entire seismic PRA can be replaced by expert judgment and experiences of similar applications. In practice, experience shows that the seismic risk remains low if seismic design is performed for the plant in accordance with good practices. In this case, the documentation of expert judgment and the seismic PRA plan would be sufficient as a part of design-phase PRA for the construction licence.

Requirement 503: The plant delivery typically includes the development and application of PRA during the design and construction of a nuclear power plant. The objective is to assess the capability and methods of the licence applicant in order to ensure that the design-phase PRA meets the Finnish safety requirements.

3 International provisions concerning the scope of the Guide

The requirements of Guide YVL A.7 include the essential parts of all requirements presented in “WENRA Reactor Safety Reference Levels, 24th September 2014, Issue O, Probabilistic Safety Analysis (PSA)”.

- The requirements of Guide YVL A.7 are more extensive and more stringent in terms of the extent and requirements of risk analysis and the extent of PRA applications. WENRA, for example, does not present any numerical design objectives for the accident risk of a nuclear power plant.

IAEA has published documents of various levels providing instructions on the development and review of PRA, and use of PRA in the safety management of a nuclear power plant. In addition, IAEA has published several INSAG and TECDOC reports providing instructions on using the risk analysis to support the design and operation of nuclear power plants.

- In 2011, INSAG published report INSAG-25, *"*A Framework for an Integrated Risk Informed Decision Making Process*"*, which covers the PRA practices and applications adopted in Finland.
- IAEA has published Safety Guides for the level 1 and level 2 PRA. In addition, IAEA is preparing the Safety Guide for risk-informed decision-making.
  - "Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants", Safety standards series No. SSG-3, IAEA, 2010
  - "Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants", Safety standards series No. SSG-4, IAEA, 2010

Guide YVL A.7 essentially contains the same requirements as the USNRC guides concerning risk-informed decision-making. In terms of methods, the NRC guides are much more detailed.

- Risk-informed decision-making is also discussed in the instructions and standards published by ASME and ANS.

Risk-informed decision-making is also discussed in the instructions and recommendations published by ENIQ.

4 Impacts of the Tepco Fukushima Dai-ichi accident

Requirement 310 of the Guide requires analysis of long-term accidents. Also, in the phenomena dealt with in the level 2 PRA, overpressure is presented as a possible reason for containment leak.

5 Needs for changes taken into account in the update

The needs for changes due to changes made to international and national laws/regulations and the change proposals made in connection with the preparation of the YVL Guide implementation decisions (SYLVI) together with others recorded in STUK's change proposal database have been considered when updating the requirements. In addition, the possibilities to reduce the so-called administrative burden have been considered.

The guide update was implemented using a limited circulation for comment because the requirement level of the Guide does not change significantly. A few requirements were specified and clarified, and the terminology was unified. It was also ensured that references to and from other Guides are sufficient and meaningful in terms of their content. For example, requirements relating to training are presented in Guide YVL A.4, and Guide YVL A.7 only includes a general requirement for the use of PRA in the planning of training and a reference to Guide YVL A.4.

The requirements of the Guide do not contain any possibilities for administrative burden reduction.