
Safety evaluation of the Finnish EPR project

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Abstract:

A permit to construct a new nuclear power plant in Finland was granted to Teollisuuden Voima Ltd by the Government in February 2005. The permit was granted after STUK (Radiation and Nuclear Safety Authority in Finland) had issued its statement on the safety of the new plant. The statement was based on extensive effort to review the design of the plant. Main safety characteristics were reviewed already during the feasibility studies in late 90's and TVO's Decision-in-Principle application and early 00's, and the detailed safety case as represented by the PSAR was reviewed in 2004. In its statement STUK concluded that there are no safety related obstacles for granting construction license to Olkiluoto 3

1 BACKGROUND

STUK started its evaluations of the EPR design at the end of the 1990s when Teollisuuden Voima Ltd (TVO) began a feasibility study for the construction of a new nuclear power plant. In the fall of 2000, TVO applied for a Decision-in-Principle to build a nuclear power plant in the power range of 1000-1600 MWe on either the Olkiluoto or the Loviisa site. In February 2001, STUK issued a preliminary safety assessment required by law for the Decision-in-Principle. Six different light water reactor concepts, the EPR among them, were preliminarily reviewed by STUK. Every concept required modifications to satisfy all Finnish safety requirements. The Government made its Decision-in-Principle on 17 January 2002 and it was ratified by the Finnish Parliament on 24 May 2002.

After receiving the Decision-in-Principle, TVO asked major nuclear vendors for bids for the plant. TVO received bids from three major vendors for four different designs, two BWRs and two PWRs. During the course of bid evaluation meetings were held between STUK, TVO and prospective vendors to resolve a few remaining licensability and/or other major technical questions. Ultimately, TVO selected the EPR design offered by a Consortium of Framatome ANP and Siemens AG (CFS). TVO submitted a Construction Permit application to the Ministry of Trade and Industry (KTM) in early 2004 to build an EPR reactor in Olkiluoto, naming the unit Olkiluoto 3 (the site already hosts two Asea Atom BWRs commissioned in early 1980's).

Construction Permits of nuclear facilities are granted by the Government, and for preparing the Government decision KTM (the Ministry of Trade and Industry) needs from STUK a statement on the safety of the planned facility (considering design features and other relevant issues). TVO submitted the documentation needed for safety assessment to STUK

in January 2004. The documentation consists of a preliminary safety analysis report (PSAR), a safety classification document and a probabilistic safety analysis, as well as other documents related to quality assurance during design and construction, preliminary plans for emergency preparedness, physical protection and safeguards and regulatory control possibilities during construction.

STUK issued its statement together with a safety assessment report to KTM in January 2005. STUK did not foresee any safety related obstacles for a Construction Permit. Reaching this conclusion required an intensive review of the Olkiluoto 3 design during 2004 and the beginning of 2005, and further design modifications were introduced to fulfil Finnish safety requirements. The Government granted the permit on 17 February 2005.

2 STUK'S DESIGN REVIEW

STUK's design review was focused on the design basis of the plant, analysis of transient and accident behaviour and analysis of radiological consequences of normal operation, transient and accident conditions. In addition, application of redundancy, diversity and separation principles in systems significant to safety to be able to meet failure criteria in abnormal conditions was carefully examined. Much emphasis was placed on issues concerning severe accidents and a large aircraft crash.

To complement STUK's own review and to get independent evaluation of the design, STUK contracted external organisations and experts to study various specific topics. Research organisations in Finland (Finnish Technical Research Centre, VTT) and in Germany (Institute for Safety and Reliability, ISaR) were asked to perform transient and accident analyses for some of the most limiting cases. ISaR also gave a requested expert opinion on the design of emergency core cooling systems. Based on the results of the transient and accident analyses performed by independent organisations using different analysis tools and models, it could be concluded that the vendor analyses were adequately conservative.

STUK also contracted the German research organisation, Gesellschaft für Anlagen und Reaktorsicherheit (GRS) to perform analysis of the protection against aircraft crashes and to evaluate the Break Preclusion concept applied in primary and secondary systems. Furthermore, STUK hired Lappeenranta University of Technology to study the functionality of the molten core spreading area cooling system. In addition, STUK asked advice on topics outside STUK's expertise: a review of programmable digital systems, protection against electromagnetic interference, high electro-magnetic pulses, human reliability analysis and weather phenomena, to mention a few. Results of these studies, tests and experts' advice were incorporated with STUK's review.

During the review, STUK had numerous meetings with TVO and CFS on various topics. As a result of these meetings and several audits of the CFS design processes, STUK was able to get familiar with the capabilities of the CFS and TVO to manage the project. Audits, mostly conducted by TVO with STUK participating as an observer, resulted in several remarks. CFS managed to resolve the most significant findings prior to STUK's statement.

3 CHANGES IN THE DESIGN

As a result of the review, STUK indicated that the reliability of certain safety functions needed improvement. This led the vendor to propose design modifications that provided additional diversity, redundancy or separation in these functions. Some examples are given below.

One of the changes was related to the consideration of large break LOCA in the design basis of the plant: in essence, LB LOCA was retained as a Design Basis Accident. STUK required pipe whip restraints to be implemented in the primary systems to complement the Break Preclusion concept. In addition, consequences of a guillotine 2A LOCA to the cooling of the core and radioactivity control were to be analysed. Provision against severe accidents had to be improved by doubling the dedicated depressurising valves and by significantly simplifying the design of the spreading area floor construction. The management of hydrogen in the two compartment containment was also challenging. Analyses concerning hydrogen distribution and margins against hydrogen explosions in the containment resulted to the installation of additional hatches on the top of the steam generator compartments to guarantee adequate distribution of hydrogen in the containment. With regard to airplane crashes, the design was required to withstand a crash of a large passenger or military aircraft without direct radioactive releases to the environment. While the EPR basic design provided a good starting point here in terms of general layout, changes were anyway incorporated in the design during the review to increase wall thicknesses, distances between the inner and outer walls of the safety and fuel buildings, robustness of the pumping stations, and protection of air intakes from fuel ingress.

In the accident analysis area, management of steam generator tube ruptures was modified to minimise direct releases into environment. STUK also paid attention to the sump design, requiring provision of backflushing capability to clean the filter, and followed closely the tests performed to verify the proposed design. Built-in backflushing is the only known reliable means to ensure undisturbed sump performance and hence long-term cooling of the core after a LOCA. In the automation area, the review focused on the architecture and functions of the different I&C systems, especially on the application of diversification and separation (e.g. use of sensors) between the protection system and its diverse back up. STUK also required a simple automatic hardwired back up system to cope with a total loss of digital I&C.

Regarding the separation requirements of the electrical systems, safety classified electrical cables were to be physically separated from the non-safety cables. Separation of electric supply from the DBA systems and systems dedicated to severe accidents were improved. As a separate joint project with the Finnish national grid operator Fingrid, a gas turbine will be constructed on site to provide independent AC power to all units. Additional fire walls are to be constructed in the annulus area to separate redundancies from each other. Some modifications were necessary due to Finnish weather phenomena. For example, the air intakes of the emergency diesel generator, and the cooling systems had to be protected against snow blocking.

4 CO-OPERATION BETWEEN FRENCH REGULATOR AND STUK

Ever since TVO chose the EPR, STUK has had close co-operation with the French safety authority DGSNR and its technical support organisation IRSN (co-operation existed earlier, as well, but then common interests were fewer). Current co-operation consists of meetings and exchange of information on the review results of specific design topics (severe accidents, automation, air craft crashes, etc.) important in seeking a common position. Furthermore, a STUK representative has been nominated a member of the French Standing Committee on Reactors (GPR). DGSNR also provided STUK with the results of the French and German safety authorities' work in developing the basic EPR design criteria during the 1990's. Meetings were also held with DGSNR's pressure equipment section (BCCN) to exchange information on the design and manufacturing of primary components. STUK considers this information exchange with DGSNR and IRSN very useful and looks forward to

continuing this work during the construction period.

5 RESULTS OF THE REVIEW

Based on the review results, STUK found no safety related issues preventing a Construction Permit. STUK's safety evaluation concluded that the Olkiluoto 3 can be build so that its operation poses no harm to employees, general public or environment if the provisions and commitments made in the PSAR are duly followed. STUK also noted that there are improvements in the safety design compared to the currently existing plants. Use of redundancy in the safety systems, subsystems systematically separated from each other, together with extensive use of diversity in functional level forms a basis for improved safety. The explicit dimensioning of the containment (and other safety-related buildings) against severe accidents and aircraft crashes is a step forward as well.

However, in its statement STUK set some conditions. As the detailed design of the plant continues during the construction period, STUK must be able to oversee the project properly; in spite of the very ambitious construction schedule enough time must be reserved for STUK to perform its regulatory activities (approval of detailed design). Concerning waste management, more detailed plans taking into account the effects of the new unit in the existing waste management plans are required. STUK also pointed out that TVO must develop and maintain its expertise at an adequate level during the construction and operating phases of the new unit. Furthermore, STUK remarked that the Finnish society needs a commitment to maintaining the nuclear safety infrastructure, sufficient higher-education and basic research within the field of nuclear technology.

6 CRITICISMS

The new power reactor project has all along drawn the attention of nuclear energy critics such as Greenpeace, Friends of the Earth and IPPNW. These organisations have issued statements along various phases of the project, including decision-in-principle (several but relatively superficial) and the construction permit (few but relatively thorough). Main topics raised pertain to severe accident management, use of digital I&C, and coping with external threats, in particular terrorism.

STUK's construction permit statement and its supporting documentation were independently reviewed by Greenpeace, which hired a British consultant well known for his critical voice. The consultant failed to find any such shortcoming or safety issue that would not have been addressed by STUK's review already. Same applies to other criticisms received so far.

Generally, it is worth noting that the Finnish three-step licensing process allows extensive discussion among and participation of all stakeholders during very early phases of the project, and it has proven very effective in establishing a societal consensus and broad commitment. As an example, the construction permit was granted by a government consisting mostly of ministers, including the prime minister, who during the previous parliament term had voted against the decision in principle on the Olkiluoto 3 project.

7 WORK CONTINUES

The review of the design has been a major challenge for STUK's staff. STUK has used more than 30 man-years for the review in 1999-2004. From January to August 2005, 15 additional

man-years have been spent on further reviews. The design of the plant is not yet in all respect completely finalised. STUK's regulatory control and approval process focuses both the design/implementation and project management activities and continues during the construction. STUK will review and approve the detailed designs of the safety-significant systems, structures and components (SSC). The start of manufacturing of SSCs is not allowed prior to STUK's approval. This is a major challenge for the project due to the tight construction schedule. In addition to the approval of the detailed design documentation, STUK will approve manufacturers for the most significant pressure equipment, installation and commissioning of the equipment, and inspect the manufacturing processes. STUK will also perform inspections on the construction of the most significant civil structures. In the electrical and I&C area, STUK controls the design and manufacturing processes of the equipment, verification and validation of the software and systems, tests off site as well as the installation and commissioning on site.

STUK has established a Construction Inspection Programme concerned with the project management and working processes of TVO. The inspection framework covers the construction period and detailed inspection plans will be established semi annually. The Programme consists of inspections for example on TVO's project management, use of resources, handling of safety issues, decision making, quality management and control, and training.

TVO is expected submit an application for an Operating License in late 2007. A fuel loading and the start of a trial run will follow the granting of the Operating License, scheduled in late 2008. In the operating license phase, TVO will submit the licensing documentation to STUK for review and approval. STUK will again give a statement on safety to KTM, before the Government can issue the Operating License.

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