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Supplemental to SAFIR 2014 Framework Plan resulting from the Fukushima nuclear power plant accident

The SAFIR2014 research programme focuses on issues enhancing national nuclear safety know-how and competence, particularly with a view to meeting the needs of the nuclear safety authority. Separate plant unit-specific technical support is being conducted and commissioned by authority and licence holders. Such surveys remain beyond the scope of this research programme. The programme drawn up in 2010 will be supplemented with research topics of current interest, as described in this appendix. These topics are based on the needs for additional research outlined by the Reference Groups and Steering Group under the SAFIR2014 programme, and other issues that have emerged.

Some research topics supplementing the Framework Plan [1] are considered to be of topical interest and suitable for the SAFIR2014 research programme. These are presented below.

Initiating events: external threats and multiple failure events

Greater depth is required in assessing the occurrence and consequences of external natural events. Research must be continued on events causing exceptionally high water levels on the Baltic Sea, and their consequences. Other extreme natural events forming suitable research topics include the impact of the atmosphere's composition on the intensity of weather events. They also include the occurrence of events previously uncharacteristic of Finnish weather patterns, such as ice storms and hurricanes. Such topics broadly cover factors affecting the probability and intensity of natural events, as well as the adequacy of nuclear power plant design principles during various types of event.

Multiple failure events are an area not dealt widely within the current research programme. New information is needed on combinations of external events, as well as combinations of external and internal events, for inclusion in risk analyses of power plants.

Design of nuclear power plants

The adequacy and scope of nuclear power plant design basis must be reviewed at regular intervals. In the research area covering the impact of earthquakes, initial data should be investigated, such as the damping function, which affects the calculation of seismic models. Objectives and requirements for a measuring system suited to long-term seismic measurement of the plant site have been described in a general level in international guidelines. Research is required to specify these guidelines and create a clear overall picture of the importance and monitoring of seismic phenomena under Finnish conditions.

New information is also needed on the impact of beyond design basis initiating events on nuclear power-plant safety. This research should address loading of various types

of components and structures, the integrity of safety functions after exposure to high loads, and plant performance after exceeding the design basis (cliff edge effects). The dependence of safety functions on electrical systems, especially the plant behaviour in loss of DC power, should be studied. Components' fail-safe assumptions should be investigated as well.

In research related to nuclear power plant design, insights based on both deterministic and probabilistic approaches have to be taken into account.

Mitigating the impact of accidents

Investigation of accidents should include analyses with high concentration of boron or other crystallisable substances are in the reactor circuit. A prolonged accident poses new kinds of challenges to decay heat removal. Better knowledge is required on potential hydrogen formation, hydrogen transport within the containment, leakage from the containment and transport within plant premises or on the plant site during accidents, in order to plan counter-measures related to hydrogen explosions. Both deterministic and probabilistic modelling should be further developed to account for prolonged situations.

In accident condition with core melt, a large number of different fission products may be released from the fuel, depending on the circumstances. A systematic analysis should be performed covering the largest possible range of fission products released from nuclear fuel, transport in the primary circuit and containment building, and release into the environment.

Life cycle of fuel

For the time being, the life-cycle analysis of fuel has been limited to issues of long-term storage of nuclear waste conducted within the Finnish Research Programme on Nuclear Waste Management (KYT2014 programme), carried out alongside the SAFIR2014 research programme. In the future, nuclear safety research should consider the overall life cycle of the reactor fuel as part of nuclear power plant safety. A situation involving loss of the cooling water supply for the plant site's spent fuel pools would provide an interesting subject for experimental and computational analysis. This area of application is totally new in reactor safety research programmes. In addition to cooling, there is a need for the ability to estimate the behaviour of fuel cladding materials in various stages and conditions in the case of both wet and dry storage. This may require both experimental and computational analysis, as well as method development.

Reference:
1. SAFIR2014 Framework Plan: http://safir2014.vtt.fi