STATUS OF BURNUP CREDIT IMPLEMENTATION AND RESEARCH IN SWITZERLAND

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Abstract

Burnup credit has recently been approved by the Swiss licensing authority for the spent-fuel storage pool of a PWR plant for fuel exceeding the originally licensed initial enrichment. The criticality safety assessment is based on a configuration consisting of a small number (approximately a reload batch) of fresh assemblies surrounded by assemblies having a burnup corresponding to the minimum value in the top 1 m section after one cycle of irradiation. The allowable initial enrichment in this configuration is about 0.5% higher than for all fresh fuel. A central storage facility for all types of radioactive wastes from Switzerland, including cask storage of spent fuel assemblies is being commissioned presently. The first applications for licenses for casks to be used in this facility have been submitted. Credit for burnup has not been requested in these applications (conforming to the original licenses of the casks in their countries of origin), but utilities are interested in burnup credit for fuel with higher initial enrichments. Reactivity worth measurements as well as chemical assays of spent fuel samples in the LWR-PROTEUS facility at PSI are in detailed planning currently. The experiments, scheduled to start in 2001, will be performed in cooperation with the Swiss utilities and their fuel vendors. Although the focus of interest of these partners is on validation of in-core fuel management tools, the same experiments are also applicable to burnup credit, and contacts with further potential partners interested in this field are underway.

1. GENERAL SITUATION OF SPENT FUEL MANAGEMENT IN SWITZERLAND

Spent fuel from all the Swiss nuclear power plants (3 PWR's, 2 BWR's) has been stored in pools at the reactors. The PWR's have been refurbished with high-density racks employing absorber sleeves with boron-containing materials. A substantial part of the spent fuel, though varying from plant to plant, has been shipped to France and the United Kingdom for reprocessing. A central storage facility for all types of radioactive wastes, called "Zwilag" (from the German word Zwischenlager, i.e. intermediate storage), which also provides room for dry storage of spent fuel in casks, has recently been commissioned. The first spent fuel shipments to this facility are planned for the near future. Utilities are considering an increase of long-term storage of spent fuel, particularly if this alternative proves economically more attractive than reprocessing (after fulfilling the existing contracts). Planning and geological investigations for the disposal of radioactive wastes in Switzerland are performed by NAGRA, a co-operative formed by the nuclear utilities and the federal government (responsible for wastes from medicine, industry and research). A repository for high-level wastes is not expected to become operational before the year 2040.

All transports of spent fuel from Swiss reactors to date have been to foreign reprocessing plants. Moreover, no transport containers have been originally designed and licensed in Switzerland. For these reasons, licensing of transports is not done completely independently in Switzerland. Rather, licensing of spent fuel shipments from the Swiss nuclear power plants is based on the licences for the containers obtained in their countries of origin, and the regulations for transport and reprocessing in the receiving countries must be taken into account.

2. REGULATORY STATUS

The standards and guidelines applied for licensing in Switzerland allow the use of burnup credit. For each fuel assembly to be loaded into a spent fuel management system applying burnup credit, it must be proved, both from the reactor operating records and by a burnup measurement, that it exceeds the minimum burnup on which the burnup credit licence is based.

The licensing of storage pools is based on the US NRC Regulatory Guide 1.13, Appendix A. The containers used for away-from-reactor storage and for spent fuel transports to foreign reprocessing plants are licensed in their countries of origin. The original licences are validated for the use in Switzerland based on an independent review of the original safety assessment by the Swiss authorities, in which amongst other considerations the conformity with international standards (IAEA transport regulations) is verified.

3. CURRENT AND NEW USES OF BURNUP CREDIT, FUTURE INTERESTS

3.1. Pool Storage

Burnup credit has recently been approved by the Swiss licensing authority for the spent-fuel storage pool of a PWR plant for fuel exceeding the originally licensed initial enrichment. The criticality safety assessment is based on the fact that even in the case the core must be unloaded at the beginning of a cycle, only a small number of assemblies in the pool are fresh. Criticality calculations were performed for a small contiguous array (approximately a reload batch) of fresh assemblies surrounded by elements burnt for at least one cycle. The minimum burnup value in the top 1 m section after one cycle is assumed for these latter assemblies. Credit is taken both for actinides and fission products (except for short-lived nuclides), whereas no credit is taken for soluble boron. The allowable initial enrichment of UO_2 fuel, which was 4.40% for all fresh fuel, can be increased to 4.89% in this mixed configuration. Burnup credit is not taken for MOX fuel, because the maximum envisaged initial Pu content is less than the allowable value for fresh fuel.

No credit for burnup is taken for the storage of spent fuel in the pools of the other reactors. The existing storage pools have sufficient margin to accommodate fuel with higher initial enrichment than originally used. Credit is taken, however, for integral burnable absorbers in BWR pools, i.e., the storage pools are designed and licensed for the peak reactivity of the fuel in its lifetime under consideration of burnable absorbers.

3.2. Cask Storage

The first applications for licenses for casks to be used for spent fuel storage in the Zwilag facility have been submitted. Credit for burnup has not been requested in these applications, because they are based on the original licences of the casks in their countries of origin, and because the first assemblies to be stored are old ones with relatively low initial enrichments. However, burnup credit may become interesting in the future, when fuel with higher initial enrichments will be shipped to Zwilag. This will be the case in a few years. Negotiations with cask vendors are underway, but burnup credit has not yet been requested concretely.

3.3. Transportation

The shipments of spent fuel from the Swiss reactors to foreign reprocessing plants have to fulfil not only the Swiss licensing criteria, but also those of the receiving countries and those of the original licences of the transport casks. To date, burnup credit has only been taken by one PWR utility for shipments to France. In this case, the same criteria as in the French regulations are applied for fuel whose initial enrichment exceeds the originally licensed limit of the casks and of the reprocessing plant.

3.4. Disposal

For disposal, burnup credit is regarded as desirable for an economic loading of the fuel assembly canisters (for the criticality safety in the case of water ingress, but intact fuel geometry). Scoping studies on possible scenarios leading to criticality after dissolution and relocation of fissile nuclides (taking into account also the moderation by the clay backfill around the canisters) as well as on the probability of occurrence of such configurations have been started by NAGRA. Burnup credit is intended also for this part of the safety assessment, but given the long time frame until the possible realisation of a repository in Switzerland, a concrete licence application is still far away.

4. RESEARCH: THE LWR-PROTEUS PROGRAMME

A programme of LWR integral experiments is currently being carried out in the PROTEUS facility at PSI. PROTEUS is a driven, zero-power facility, in which the central test zone, which contains the lattice to be investigated, is subcritical. This test zone is surrounded by driver regions containing 5% enriched fuel moderated by heavy water and graphite. The test zone and the driver are separated by a buffer consisting of tightly-packed natural uranium metal rods in air (i.e. without moderator) which helps to spectrally decouple the two regions.

The LWR-PROTEUS experiments are performed in co-operation with the Swiss utilities and their fuel vendors with 50% utility funding. In the first phase, which is about 2/3 complete, the test zone consists of 9 real, full-length SVEA-96 BWR fuel assemblies. The major part of the measurements in this phase deals with pin power distributions and pin removal reactivity worths in these assemblies. The aim of these measurements is to validate design codes for the calculation of modern assembly types which have much stronger heterogeneities (e.g. internal water regions, high number and absorber content of burnable poison rods) than most of the experiments against which the computational methods were originally tested.

In a second phase of the programme, which is in detailed planning currently and scheduled to start in 2001, reactivity worth measurements of PWR spent fuel samples will be performed. For these experiments, the central BWR assembly will be replaced by a small array of actual PWR fuel rods. Samples of burnt rods (~40 cm long) and specially prepared samples containing individual actinides or fission products or standard absorbers (for calibration) in a UO_2 matrix will be oscillated in the centre of the test zone. The burnt samples will be held in a special cask placed on top of the reactor incorporating a remotely controlled oscillator. UO_2 rods from a Swiss PWR with burnups up to 82 GWd/t are available at PSI. MOX samples (up to ~50 GWd/t) will also be measured. In addition to the reactivity experiments, chemical assays of these samples will be performed in the PSI Hotlab. Although the focus of interest of the utility and industry partners is on validation of in-core fuel management tools for high burnups, the same experiments are also applicable to burnup credit, and contacts with further potential partners interested in this field are underway.