RRFM 2008 Hamburg
European Nuclear Society

High Scientific Council position paper on Research Reactors

RRFM is a yearly occasion to review the status, operation and evolution of the research reactors in the world, including Material testing reactors (MTRs) and irradiation facilities, neutron sources for condensed matter studies, reactors for radioisotope production, reactors for education and training, and critical mockups for Reactor Physics. The overall number of research reactors in the world is decreasing, as many reactors are ageing and are not being replaced. It is hoped that a stabilization will occur soon: a further decrease of the fleet could be detrimental to the community. In this context of reduction of research reactors, the principle of coalitions is proposed and promoted by IAEA, to give access to a reactor to several neighbouring countries. Such coalitions could be most effective in Latin America and in Africa.

In Europe, there are only three big projects of research reactors : the Jules Horowitz Reactor in Cadarache (France) intended to replace the ageing Materials Testing Reactor OSIRIS in 2014, the PALLAS facility, intended to replace the High Flux reactor in Petten, and the MYRRHA project, dedicated to the study of accelerator-driven subcritical cores. Good news from the Jules Horowitz Reactor (JHR) project have been reported, as the financial aspects of the project are settled, with participation from many countries, including India. Whereas the construction of the JHR has already begun, the status of PALLAS and MYRRHA is more uncertain.

The biggest issue of the conference was the progress made in the conversion of the cores of Research Reactors from High Enriched uranium (HEU) to low Enriched uranium (LEU). The program of core conversion has been initiated in 1978 under the auspices of the US Department of Energy. It supports the minimization and, to a possible extent, the elimination of the use of HEU in civilian nuclear applications.
As of 2008, an overall of 207 research reactors are concerned in the world. 56 have already been converted, 78 are beyond scope, and 46 are planned for conversion with existing LEU fuel. The remaining 28 are high performance reactors, also planned for conversion but these will need fuel of a new type to comply with core conversion without losing too much in performance. The challenge for this new fuel development has been extensively examined during the conference.

The permanent challenge of research reactors devoted to test or irradiation is to produce high neutron fluxes with limited amounts of fissile material. By itself, this constraint already points out to the need for fuels with a high density of fissile matter. Conversion of research reactors cores to LEU has rendered the need for dense fuel even more stringent. The intermetallic compound U_3Si_2 is presently the reference fuel, with a well mastered fabrication process at the industrial scale and a good behaviour under irradiation, but its density is only 4.8 $gU.cm^{-3}$, and this is clearly not sufficient for the conversion of some of the more demanding research reactors. Higher densities can be reached by switching to UMo alloy, where the 7-10% Mo additive has been chosen for its capacity to stabilize the gamma phase of uranium. Monolithic UMo alloy has a density as high as 16 $gU.cm^{-3}$; UMo can also be made of powder, sandwiched between two colaminated plates of Al. The density of the powder (called “meat” in the specialist’s jargon) at the center of the sandwich is then limited to about 8 $gU.\ cm^{-3}$. The behaviour of this type of fuel plates has been tested under irradiation in various laboratories, with not yet completely satisfactory results. The general finding is that the Al matrix interacts with the UMo alloy to form an interaction layer where the gamma phase of the uranium crystal lattice is locally destroyed, with negative consequences on the behaviour of the fuel under irradiation (the swelling and pillowing of the fuel plate can modify the cooling of the fuel and cause its buckling; the fission gas release can cause blistering of the plate, and cause its ultimate rupture). The addition of 2-5% of Si either in the Al matrix or in the UMo itself seems to limit both the development of this indesirable, mainly amorphous interaction region, and its consequences in terms of swelling. Reports from all laboratories confirm the positive role of Si on the fuel behaviour under irradiation. The phenomenology of the role of silicon is being better mastered, as silicated phases located at the interface between UMo and Al play the role of a diffusion barrier which limits the development of the amorphous interaction layer. Cumulated fission rates as high as 5.10^{21} fissions.cm^{-3} in the fuel grains, corresponding to burnups of 10 %, have been achieved with UMo fuels under the form of powder. Alternatives to the aluminium cladding have been researched (stainless steel, zirconium alloy), with promising results so far. Altogether, the UMo fuel is by no means produced, even less qualified on the industrial scale. It is hoped that the promising recipe of Si addition will ultimately result in a well mastered fabrication process, with satisfactory fuel performance under irradiation, but progress is slow. Some of the more advanced research reactors will have to wait for this new type of fuel to achieve their core conversion.

The US National Nuclear Security Administration recently issued a request for information, or RFI, on the nuclear industry's capability to fabricate very-high-density low-enriched UMo fuel for research and test reactors. According to the very ambitious schedule in the RFI, the qualification of monolithic fuel for use in US reactors by the US Nuclear Regulatory Commission is anticipated in 2011.

The RRFM conference was not entirely devoted to core conversion. A significant part of the communications was devoted to core calculation. The 2008 edition of the conference has confirmed the generalization of the use of Monte Carlo codes for the neutronic calculations. Coupled neutronic-thermal hydraulic (NTH) calculations are more and more frequently undertaken. The IAEA has proposed to launch a Coordinated Research Project (CRP) devoted to the benchmarking of these NTH calculations. The European Nuclear Society welcomes this initiative, and will follow its developments.

The High Scientific Council of the European Nuclear Society