AMSTER : A Molten-Salt Reactor Concept Generating its own ^{233}U And Incinerating Transuranium Elements

J. Vergnes*, C. Garzenne*, D. Lecarpentier, H. Mouney*****

EDF-R&D.Département Physique des Réacteurs 1 Avenue du Général de Gaulle 92140 CLAMART France; email: jean.vergnes@edf.fr

** Ministère de l'éducation nationale, de la recherche et de la technologie, Conservatoire National des Arts et Métiers, Laboratoire de physique,

292 rue Saint-Martin, 75141 Paris Cedex 03.

***EDF, Pôle Service et Ingéniérie Etat Major CAP AMPERE,

1 Place Pleyel 93282 SAINT DENIS CEDEX

M. Delpech

CEA Direction des Réacteurs Nucléaires, Departement d'Etudes de Réacteurs, Service de Physique des Réacteurs et du Cycle,

CEA / CADARACHE, BAT 320 13108 St Paul Lez Durance.

Sustainable development of atomic energy will this coming century requires development of new types of reactors able to exceed the limits of the existing reactor types, be it in terms of optimum use of natural fuel resources, reduction in the production of long-lived radioactive waste, or economic competitiveness. Of the various candidates with the potential to meet these needs, Molten-Salt Reactors are particularly attractive, in the light of the benefits they offer, arising from 2 fundamental features:

- a liquid fuel does away with the constraints inherent in solid fuel, leading to a drastic simplification of the fuel cycle, in particular making in possible to carry out in-line pyrochemical reprocessing;
- thorium cycle and thermal spectrum breeding. The MSBR concept proposed by ORNL in the 1970s thus gave a breeding factor of 1.06, with a doubling time of about 25 years.

However, given the tight neutron balance of the thorium cycle (the η of U233 is about 2.3), MSBR performance is only possible if there are strict constraints set on the in-line reprocessing unit: all the Pa233 must be removed from the core so that it can decay on theU233 in no more than about ten days (or at least 15 tonnes of salt to be extracted from the core daily), and the absorbing fission products, in particular the rare earths, must be extracted in about fifty days.

With the AMSTER MSR concept, which we initially developed for incinerating transuranium elements, we looked to reduce the mass of salt to be reprocessed, in order to minimise the size and complexity of the reprocessing unit coupled to the reactor, and the quantity of transuranium elements sent for disposal, as this is directly proportional to the mass of salt reprocessed for extraction of the fission products. Given that breeding was not an absolute necessity, because the reactor can be started by incinerating the transuranium elements from the spent fuel assemblies of current reactors, or if necessary by loading just as much U235 as is needed, we aimed to optimise core design to obtain self-generation (breeding factor = 1), while relaxing the constraints on the reprocessing unit as far as possible: no more extraction of Pa233, minimisation of the mass of salt to be reprocessed daily (no more than a few hundred kg, for a reactor with the power of the MSBR: 1 GWe), which also has the advantage of relaxing the design requirements concerning reprocessing loss rates, which could remain appreciably the same as those obtained with the hydrometallurgy reprocessing techniques (10^{-3}), while guaranteeing excellent performance in terms of reducing the quantity of long-lived radionuclides sent for disposal.

We also examined the possibility of a mixed thorium-uranium composition, calculating the maximum uranium fraction that would sustain self-generation. This thorium-uranium fuel has the two-fold advantage of making better use of natural resources, while helping combat proliferation by lowering the concentration of fissile isotopes in the uranium.