CONVERSION PROGRAM IN SWEDEN

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ABSTRACT

The conversion of the Swedish 50 MW R2 reactor from HEU to LEU fuel has been successfully accomplished over a 16 cycles long process. The conversion started in January 1991 with the introduction of 6 LEU assemblies in the 8*8 core. The first all LEU core was loaded in March 1993 and physics measurements were performed for the final licensing reports. A total of 142 LEU fuel assemblies have been irradiated up until September 1994 without any fuel incident.

The operating licence for the R2 reactor was renewed in mid 1994 taking into account the new fuel type. The Swedish Nuclear Inspectorate (SKI) pointed out one crucial problem with the LEU operation, that the back end of the LEU fuel cycle has not yet been solved. For the HEU fuel we had the reprocessing alternative. We are now relying heavily on the success of the USDOEs Off Site Fuels Policy to take back the spent fuel from the research reactors. We have in the meantime increased our intermediate storage facilities. There is, however, a limit both in time and space for storage of MTR-type of assemblies in water.

The penalty of the lower thermal neutron flux in LEU cores has been reduced by improvements of the new irradiation rigs and by fine tuning the core calculations. The Studsvik code package, CASMO-SIMULATE, widely used for ICFM in LWRs has been modified to suit the compact MTR type of core.

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BACKGROUND

The Swedish R2 reactor is a 50 MWth materials testing reactor of pool type. It has been in operation since 1960. The reactor is used for material testing, fuel testing, isotope production and silicon doping. It has 9 horizontal beam tubes giving thermal neutrons for research work. The reactor and the Hot Cell Laboratory are since 1992 operated by a private company Studsvik Nuclear AB, which is a subsidiary of the largest utility in Sweden, Vattenfall AB.

TRANSITION TO LEU FUEL CYCLE

The R2 reactor has now since the introduction of LEU in January 1991 operated with 58 different high power cores. There has been good agreement between the calculated flux and power distributions and the measured ones after the conversion was completed in March 1993. The calculated k_{eff} has during the transition period slowly but steadily become closer to 1.0 indicating improved agreement on the power and depletion with an increasing number of LEU fuel elements. No fresh HEU fuel has been added during the conversion period.

During this period the number of fuel elements in the core has varied between 47 and 49 plus 6 control rod follower. These cores have had 9 to 11 irradiation positions in the 8x8 core matrix. Compare Figure 1.

The loading principles for the cores have changed in a rather pragmatic way with the requirements of the different experimental positions guiding the loading. This means that the radial power peaking has decreased, as the irradiation facilities moved to the periphery of the cores.

THE BACK END OF THE LEU FUEL CYCLE

The possibility to send back the used high enriched fuel to US was suddenly stopped in 1988. At first this was just an annoyance for the research reactor operators, which we thought would be solved rather expedite. After a couple of years we had learnt better. US DOE has together with the research reactor operators in the Edlow group put much effort into reopening the Off-Sites Fuel Policy. We have expectations that it will be solved with the EIS (Environmental Impact Statement) in the end of 1995.

In the meantime many operators have problem with the storage capacity for their spent fuel. Studsvik solved the storage problem by converting one pool in an on-site storage facility for spent LWR fuel, for the R2 fuel. The construction of storage racks was rather simple and the new storage racks were in use from 1991. Already after two years it was realised that the pool capacity had to be increased and a second layer of storage racks were constructed. The two-story racks will be totally filled by the end of 1994.

This storage facility was originally equipped with cooling and cleaning systems, but we constructed a simple submersible pump- ion-exchanger system (Figure 2). This system works without daily supervision and the water is kept sufficiently clean with a six month interval between changes of the ion-exchanger cartridge.

CASMO -SIMULATE AS CALCULATIONAL TOOLS

The reduction in the thermal neutron flux with the LEU fuel necessitated improvements in the core calculations. The Studsvik code package, CASMO-SIMULATE, which is widely used for ICFM in LWRs has been modified to suit the compact MTR type of core and the special control rod follower concept.

CASMO is a two-dimensional, multigroup transport code for the calculation of the eigenvalue, flux and power distribution as a function of depletion in pin cells and on LWR fuel assemblies. The code is capable of handling fuel rods, absorbing rods and absorbing slabs. The feature of the code is the ability to perform detailed transport theory calculations in 70 groups with a standard cross section library based on ENDF/B IV and VI libraries. The code has no option for plate type fuel, but the LEU (or HEU) assemblies are easily modelled as a 18x18 rod assembly with equivalent fuel rod geometry. The flux and power mismatch between HEU and LEU fuel assemblies has earlier been studied with the CASMO-3 code

The CASMO code is normally used to produce burnup dependent, homogenized, two group cross sections for the 3-D nodal code SIMULATE or diffusion core analysis codes for PWR and BWR cores. Each of the R2 fuel types has thus been modelled and depleted to give the burnup dependent cross sections and isotopic compositions. Cross sections for the reflectors, isotope rigs and absorbers have also been determined with the CASMO code.

The SIMULATE code is an advanced 2-group nodal code for reactor analysis. It provides two or three dimensional calculations of the neutronic parameters needed for in-core fuel management and reaction rate determination. The code has several advanced features as automated expansion or contraction of the core in radial and/or axial directions. It gives reactivity coefficients for parameters such as moderator and fuel temperature and also control rod reactivity worth including shut down margin. There is explicit representation of transient Xe/I and Sm/Pm number densities and thus cross sections during varying power conditions. Local power and flux distributions within a node can be reconstructed for all nodes within 1 % RMS of a transport fine mesh solution.

We are still in the phase of testing the code system on different reference cores, but the results hitherto seem to confirm our confidence in the system.

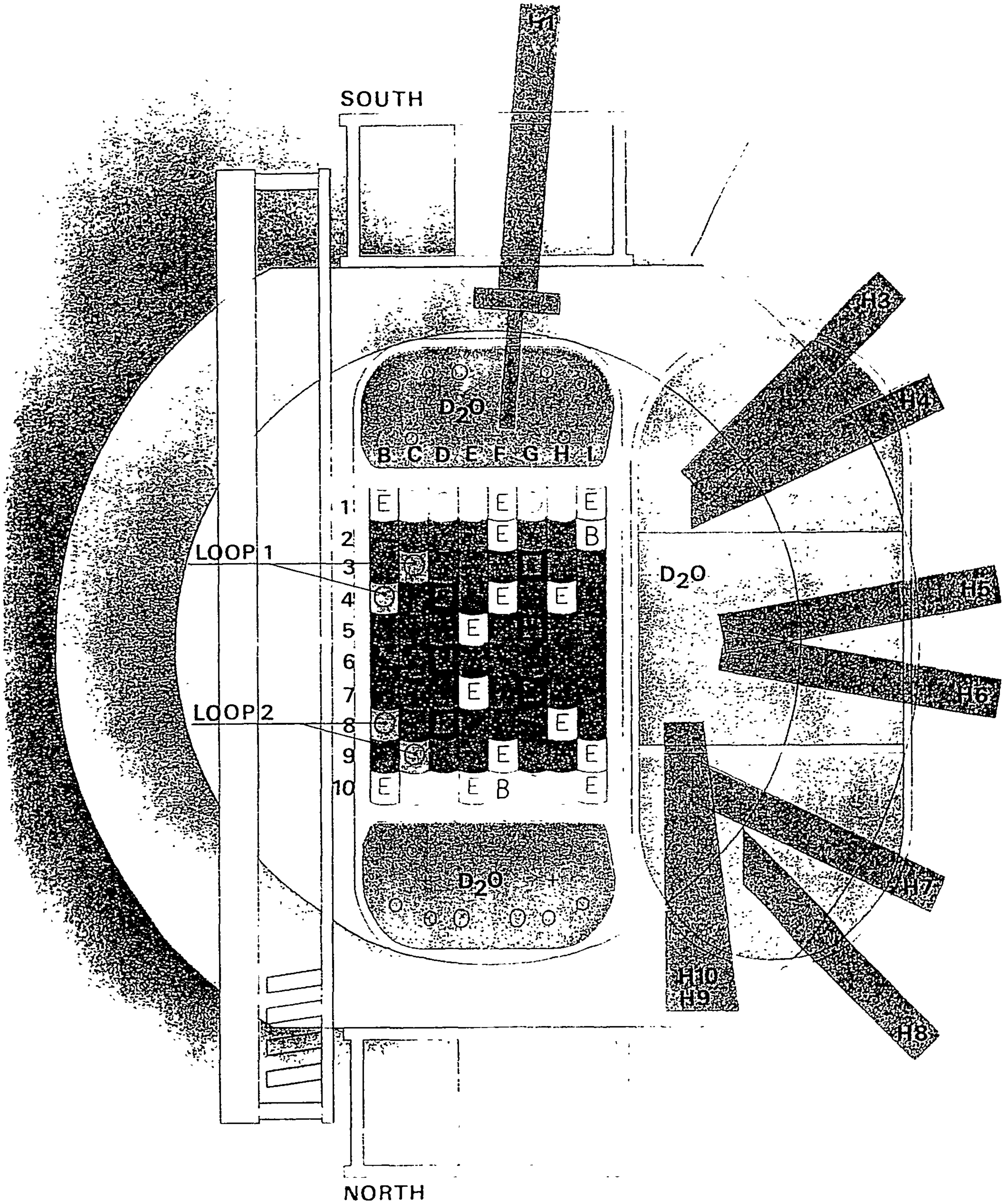

Figure 1. Schematic Layout of the R2 Core with Experimental Positions.

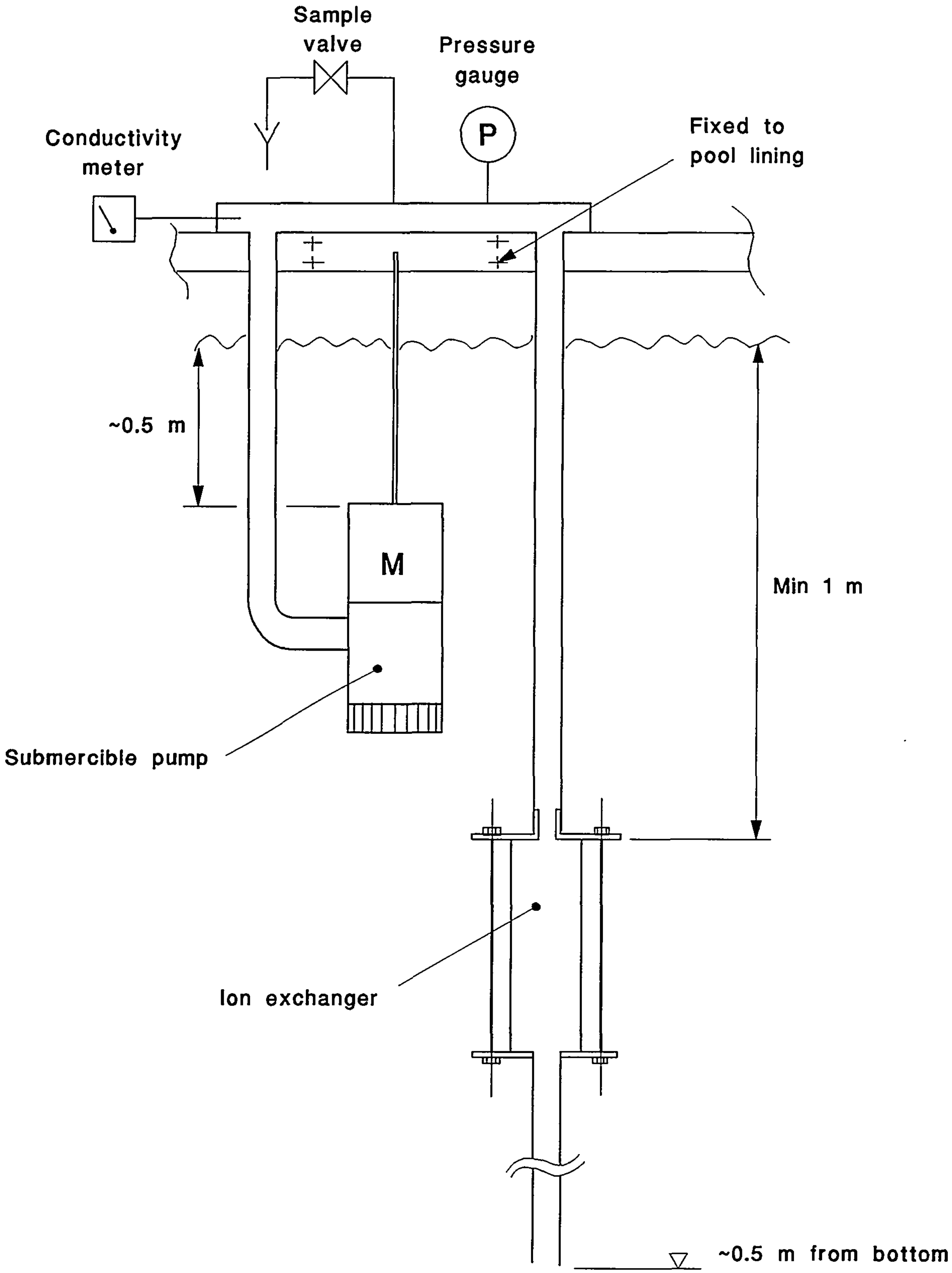

Figure 2. Layout of the Submersible Pump and Ion-exchanger System.