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THE HOT CELLS OF THE KERNFORSCHUNGSZENTRUM KARLSRUHE

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ABSTRACT

The layout and the present spectrum of tasks to be fulfilled by the KfK Hot Cells are described. Particular reference is made to the radiographic devices and to examination and disassembly of the fuel elements unloaded from the Karlsruhe KNK II reactor.

PRESENT FACILITY

At present, there are seven institutions on the KfK premises which accommodate Hot Cells: two chemical institutes, the Institute for Nuclear Waste Management Technology and the European Institute for Transuranium Elements, the Central Decontamination Plants Department, the Reprocessing Plant for Nuclear Fuels, and the Central Nuclear Plant Operations Department. Only the latter department which is operating Hot Cells for material testing purposes will be dealt with in this paper.

The KfK Hot Cells for material testing started operation at three stages of construction (Fig. 1):

- Stage 1 completed in 1966 with the heart of the facility - five concrete shielded cells with 11 work stations and 4 lead shielded cells for metallographic examinations, material testing and decontamination of irradiated specimens. The shielding of the concrete cells is made of 90 cm heavy concrete, 4.5 or 3.5 g/cm³ density; the cells are made alpha tight.
- Stage 2 completed in 1976 with another two large lead shielded cells for metallographic examinations and material testing and three smaller sized lead shielded cells accommodating two microprobes, a shielded scanning electron microscope and an X-ray diffractometer. The shielding is made of 15 or 20 cm thick lead walls; some of the cells are made alpha tight.
- Stage 3 to be completed in 1988 with rooms for manipulator maintenance and a DP center.

By 1989 a partly lead shielded glovebox system for examining tritium bearing specimens will be completed.

Meanwhile two of the old lead shielded cells mentioned before have been dismantled, one of them has been reconstructed as a modern type cell, and one glovebox for examining tritium bearing specimens was put into service even before completion of the entire facility at stage 3.

The present equipment of the concrete shielded cells allows to disassemble fuel elements as well as the usual non-destructive and destructive examinations of rods up to 2.5 m in length. A particular feature of the cells is the equipment for rod radiography. A "radiographic tower", a 380 cm high hollow cylinder shielded with 28 cm lead, is installed on top of the ceiling of cell 3 and connected gas tight with the cell (Fig. 2). The specimens to be X-rayed are inserted horizontally into a device (Fig. 3), tilted into the vertical position together with the device, transported upwards and drawn into the radiographic tower through the bore provided in the cell ceiling. They are penetrated by radiation transverse to the tower axis using a 400 kV X-ray tube or an 18 MeV betatron. If an X-ray tube is used the specimens are continuously displaced upwards in a movement synchronous to the film transport; if a betatron is used, the movement is stepwise. All transfer and transport operations are released by pressing a button.

The metallography cell is equipped with three microscopes, Leitz MM5RT, one of them with an image analyzer connected, as well as with all devices needed for specimen conditioning. The main devices of the material testing facilities are two tension-compression testing machines, two machines for low cycle fatique tests, a hardness testing device, pendulum ram

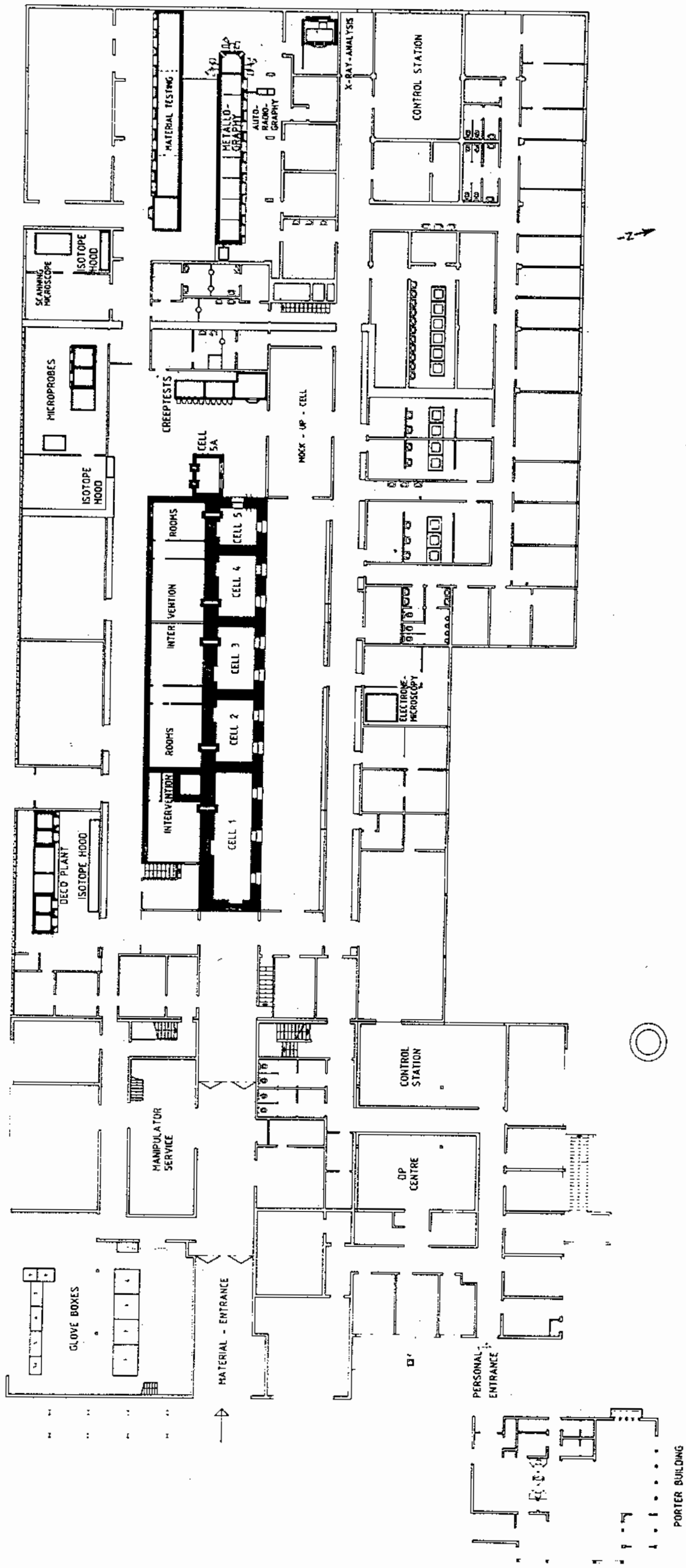

Fig. 1 Floor plan of the entire KfK Hot Cell facility.
Center: concrete shielded cells, in service since 1966.
Right : lead shielded cells, in service since 1976.
Left : lead shielded cells, gloveboxes and manipulator maintenance, in service 1988.

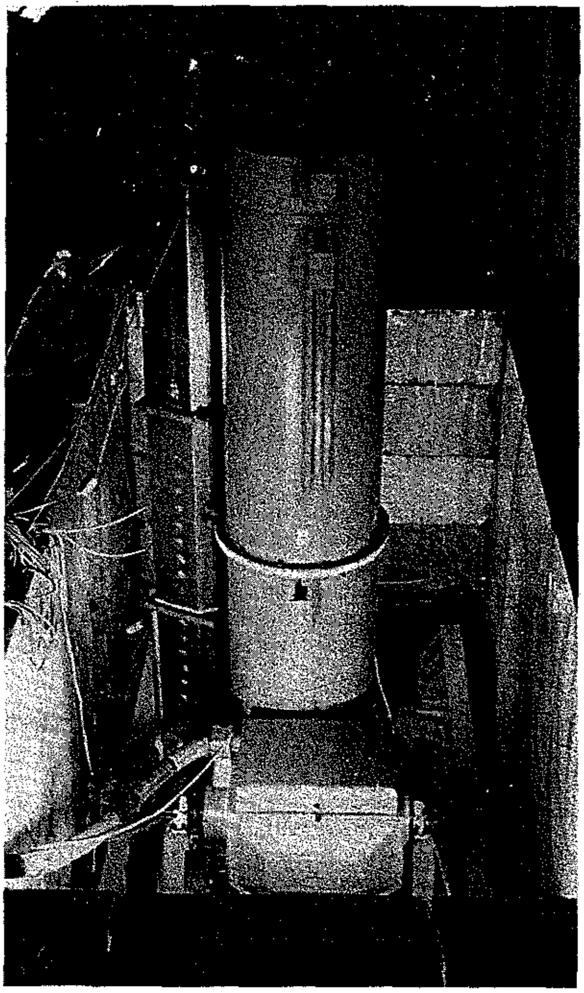

Fig. 2 Lead shielded tower with concrete brick shielding above the cell.

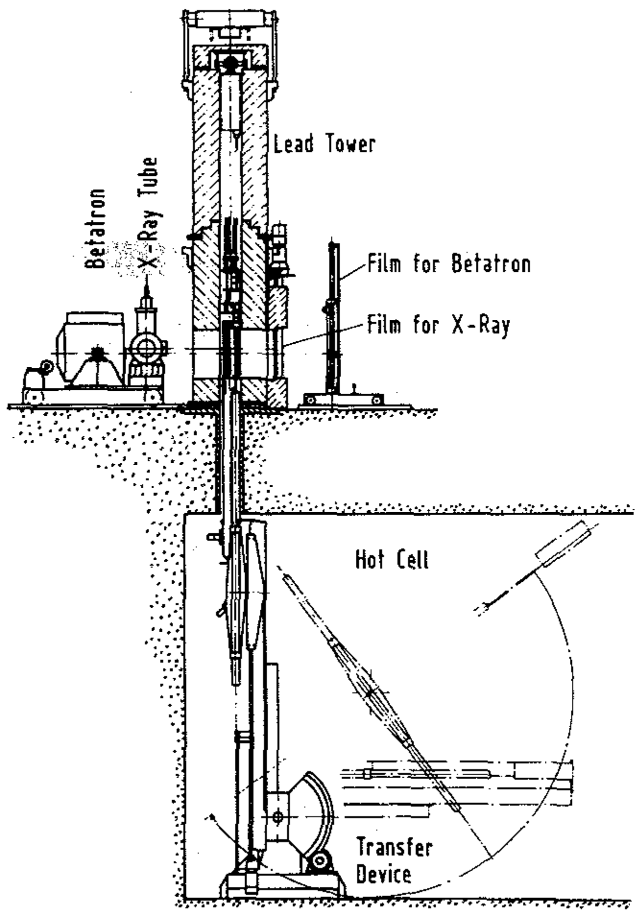

Fig. 3 Arrangement of lead shielded tower, X-ray or betatron and film holding device above the cell, pin transfer device in the cell.

impact testing machines, and 15 creep strength testing rigs.

The specimens to be examined by the microprobes, the scanning electron microscope and the X-ray diffractometer are conditioned in the metallography cell, decontaminated in the decontamination cell and prepared for examination in the devices mentioned before in lead shielded cells servicing these devices.

The values measured at presently eight work stations are gathered by computer and processed and printed by a central DP station. At the final stage of completion (1988) ten work stations will be connected to the DP center.

The concrete shielded cells and some of the lead shielded cells can be inertized with nitrogen, if needed; a purity of 50 ppm O_2 and 20 ppm H_2O can be achieved.

A rabbit system interconnects all cell facilities.

The double lid posting technique has been greatly improved; also replacement of defective power manipulators and slave arms of master-slave manipulators as well as the elimination of waste are done via double lid locks using special containers.

In 1987 an "intervention box" was put into service (Fig. 4). It can be connected gas tight to the hatches in the ceilings of the concrete shielded cells via a double lid type link. By another double lid type link a 200 l waste drum can be coupled to the box so that rather large size waste objects can be disposed

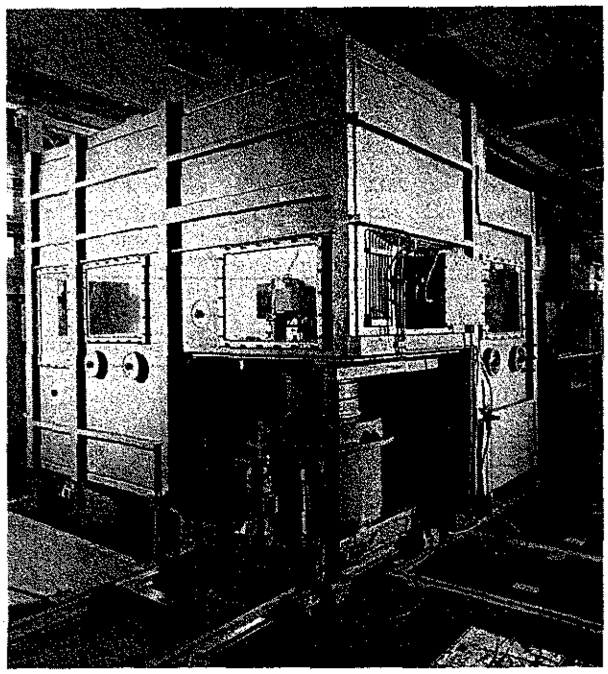

Fig. 4 Intervention box for tight connection to the cell with shielded 200 l drum coupled to it.

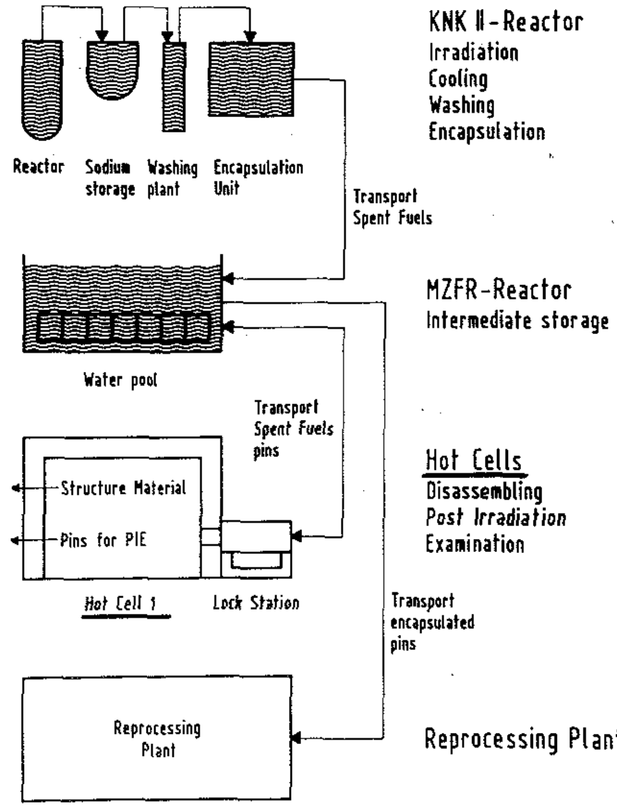

Fig. 5 The role of the Hot Cells in the disposal of the KNK II fuel elements.

of via the box without causing contamination. The box can be entered via a personnel lock so that repairs on the devices installed in the cell can be made within the box.

The number of staff of the Hot Cells Department is about 65 (six graduate scientists, 9 graduate engineers, 35 technicians, 15 skilled workers) to which another 30 staff members have to be added who are affiliated to other departments responsible for radiation protection and physical protection, repair and construction work, etc.

PRESENT PROGRAMM

The Hot Cells Department is a scientific-technical service department. It presently lends assistance to the following Projects:

- The Fast Breeder Project (PSB) ordering 80 % of all examinations, the number of orders tending to decline. The examinations relate to single fuel pins and small bundles from irradiation tests performed in various European reactors for the purpose of finding out the fuel and absorber material behaviour; besides, to irradiated metallic specimens for examinations of cladding and tank materials as well as to fuel elements from the KNK II reactor Karlsruhe, a 15 MW_e liquid-metal cooled fast breeder reactor.
- The Reprocessing and Waste Treatment Project ordering 10 % of the examinations, the number of orders tending to establish at a constant level. The solubility of MOX fuels as well as the resistance to leaching of LLW bound in ceramic and cement are tested. One of the newly erected lead shielded cells will be used to test electrolytic dissolution techniques to be applied in reprocessing.
- The Nuclear Fusion Project ordering 5 % of the examinations, the number of orders tending to rise. In early 1987 investigations started of the tritium heating and retention rates in ceramic breeding material (Li compounds) in a glovebox. Also investigations into specimens of structural ceramic have to be made.
- The Project Group by Direct Disposal of Spent Fuel ordering 5 % of the examinations, the number of orders tending to rise. This Project Group pursues the objective of disposal of entire fuel elements in salt mines with the leaching behaviour of fuel specimens in brine at high pressure and moderate temperature as the only subject investigated.

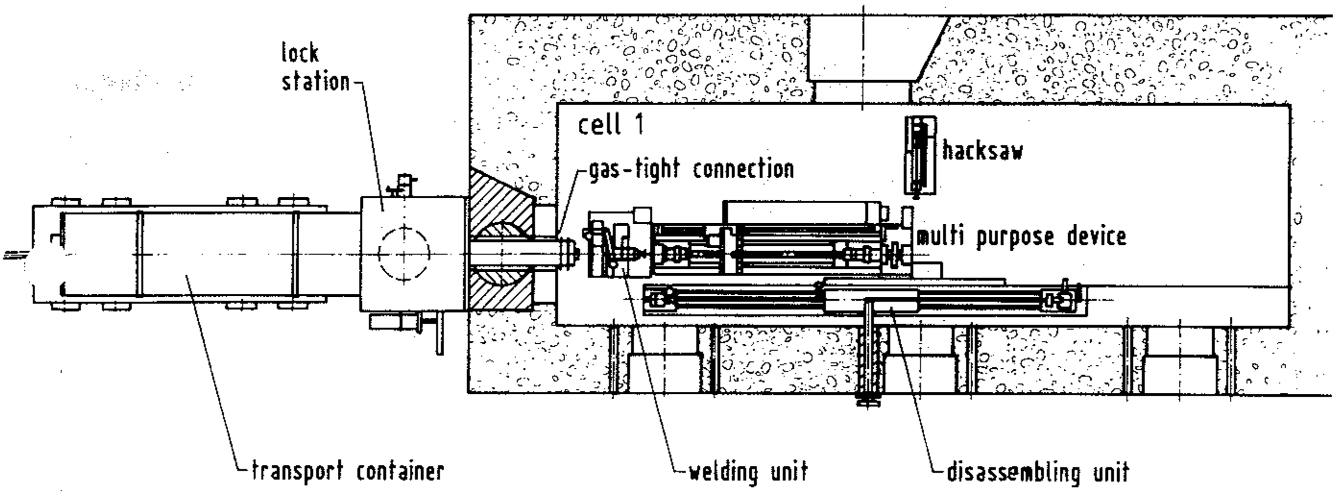

Fig. 6 Arrangement of the four large devices for transfer, measurement, disassembly and welding in cell no. 1.

The Hot Cells play a part in the disposal of the fuel elements unloaded from the KNK II reactor (Fig. 5). This has led to the largest task for the time being of the Hot Cells which is being performed within the framework of the Fast Breeder Project, namely preparatory work to the examination and disassembly of the fuel elements from the three cores of the KNK II r :tor in the concrete shielded cell 1. Each c e is made up of about 30 fuel elements the fuel of which is to be reprocessed at Marcoule (France). Work in cell 1 includes the alpha tight posting in of the fuel pins, the geometric measurement of the hexagonal wrapper tubes, singulizing of the pins, packaging and tight welding into transport capsules together with leak testing and posting out. The pins must be largely free of contamination while the capsules have to be absolutely free of contamination on the external faces and the cell is highly alpha contaminated.

These are the prerequisites of the activities mentioned above:

- Development and testing of four large devices (Fig. 6):
  - A posting station for alpha particle tight posting in of the fuel elements and posting out of the transport capsules via double lid locks with complete gamma shielding.
  - A device for geometric measurement of the wrapper tubes, for pulling the wrapper tubes off the bundles, for collecting single pins and their transfer into the transport capsules.
  - A disassembly device for pin singulizing (the fuel elements are equipped with grids as spacers).
  - A welding tool for welding the capsules and subsequent leak testing.
- Obtaining a license to handle 72 kg instead of 10 kg fissile material, a very lengthy procedure in Germany. With the new operating license granted, up to three fuel elements could be simultaneously handled in the cell.

The disassembly device has been installed in the cell since early 1986. Cold testing of the other three devices which lasted 1.5 years has just been terminated. After comprehensive measures have been taken to backfit the building, the new operating license will be granted approximately in early 1988.

Another task consits in erecting a train of six gloveboxes and four lead shielded cells at construction stage 3; planning started in mid-1987. It is proposed to take up investigations of breeding and structural materials for the NET Next Europeans Torus fusion machine in 1989. Under an EC program KfK took over the responsibility for the development of a number of ceramics.

RESULTS

Since early 1986 three KNK fuel elements have been disassembled with the disassembly device, two of them containing defective pins. The device has already proved its worth. The time required to disassemble a fuel element containing a maximum of 211 single pins is 20 hours; complete disposal of a fuel element will probably take two weeks, disposal of a KNK II core 12 months.

The relatively high capital investments needed for the consequent advancement of the double lid posting technique and for the rabbit system have proved to be beneficial in as much as they caused a considerable reduction in the man-sievert doses while improving safety. The maximum man-sievert dose in 1986 was 4 mSv (400 mrem), the collective dose received by staff members directly handling unsealed radioactive materials attained 33 mSv (3.3 rem).

The results of the post-irradiation examinations will be compiled and interpreted in other KfK institutions charged with this task.

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