

Versatile Equipment for Mechanical Testing of Active Materials

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At the Paul Scherrer Institute (PSI) 3 different project groups presently perform aging research on active materials. The research fields are fusion, high neutron flux targets and LWR relevant components. Up to now mechanical testing has been performed with small, low dose rate samples behind local shielding, not appropriate for highly activated material. To overcome this situation, a cell concept for active mechanical testing was elaborated and has been erected in PSI's Hotlab. It consists of 4 shielded cells. 3 connected cells are versatile and independently operable for highly $\beta\gamma$ -active samples. One cell is an $\alpha\beta\gamma$ -box which will be realized in a second phase. This paper presents the versatility especially of the $\beta\gamma$ -cells: The different user groups perform experiments in these cells, whereas different machines can be placed into the cells. As consequence of the need of heavily shielded cell doors, a special strengthening and levelling of the floor has been required. In all cells the relevant media are installed. Besides the performance of the cells, the project progress as the difficulties and their solutions are described.

Keywords: *Shielding, active mechanical testing, versatility*

Introduction

The philosophy of Paul Scherrer Institute (PSI) is, with regard to its big installations, that of a user-lab. The specific installations are open to different users coming from inside and outside PSI. One of the big facilities is PSI's hotlab. In the hotlab different scientific teams perform their investigations. With respect to mechanical testing there are 3 groups today: • A group from the Research Centre for Plasma Physics (CRPP), Swiss Federal Institute of Technology Lausanne (EPFL). It is a group located at PSI who performs mainly simulation irradiation of fusion relevant material and the subsequent mechanical testing. The investigated materials are, e.g., ferritic-martensitic steels, low-activation steels, ODS material. • PSI Division Spallation Neutron Source (ASQ). Materials are tested which are in discussion for windows for liquid metal spallation source targets. The main material candidates are different steels which show, for instance, high corrosion resistance against liquid Pb-Bi. • PSI Division Nuclear Energy and Safety (NES), Laboratory for Materials Behaviour (LWV), Hotlab. The focus of this group is on testing LWR material, e.g. cladding material which was exposed to high burn-up and its behaviour for intermediate dry storage. Several material testing machines of the different groups already exist at the hotlab. Until today the mechanical testing has mostly been performed behind light shielding consisting of lead brick walls. Because of increasing dose rates of samples and the wish to have the possibility to test also α -contaminated material (claddings, Pb-Bi target material) an integrated concept for mechanical testing at PSI hotlab has been developed.

Concept for active mechanical testing

The concept consists of 3 labs, whereas 2 labs are foreseen for mechanical testing and 1 lab for sample preparation (overview see Fig. 1). In one of the test labs 3 heavily shielded $\beta\gamma$ -cells are arranged in a row, individually usable. The cells are provided with doors which can be opened so that test machines can be changed. In the second test lab a heavily shielded $\alpha\beta\gamma$ -box with integrated tensile testing machine plus furnace will be installed. In this lab some additional space rests for another machine with conventional light shielding. The sample preparation lab will be equipped with a combined cell consisting of a heavily shielded $\alpha\beta\gamma$ -box connected with an α -glovebox. The room comprises also several hoods for further preparation work and storage cupboards for samples and necessary preparation chemicals.

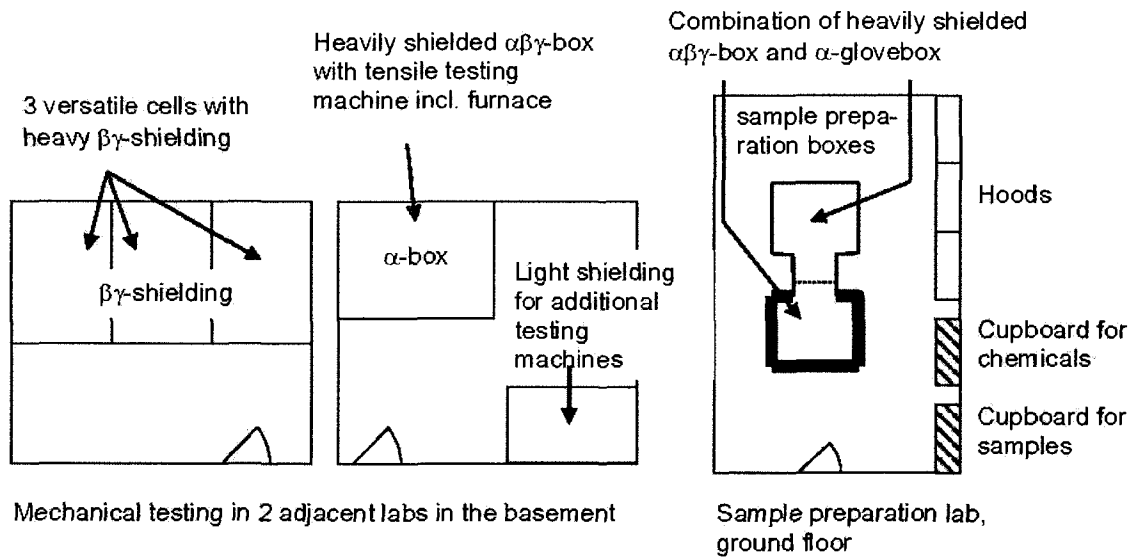


Fig. 1 Overview room concept mechanical testing at PSI hotlab

The today status of the project is: The $\beta\gamma$ -cells are erected, the concept for the $\alpha\beta\gamma$ -box for mechanical testing is developed, the testing machine including furnace for the $\alpha\beta\gamma$ -box has been ordered and the planning for the preparation lab will be done until end of September 04. In the following the description of the work is concentrated on the shielding for mechanical testing in the basement.

Versatile cells with $\beta\gamma$ -shielding

The shielding consists of 3 independently usable cells with the dimensions 200 cm (height), 155 cm (width, each cell) and 230 cm depth. The thickness of the steel walls – also between the cells – is 20 cm. Each cell is equipped with a lead glass window and 2 manipulators. The design of the manipulators is very flexible taking into account their applicability for different machines. 2 additional holes were drilled into the front walls for mounting drawers (quick transfer of smaller pieces as tools into the cell) and flanges for the docking of sample transport bottles. The additional holes are designed in a way so that also a third (linear) manipulator could be mounted. The front wall is constructed as door which can be opened for the purpose of changing testing machines. Because of lack of space, a solution had to be found for a convenient possibility to remove manipulators (some manipulators can not be stretched when a testing machine is installed; additionally the door which is adjacent to the room wall can not be completely opened because of the cold part of the mounted manipulator which reaches into the room). Therefore U-type notches have been cut at the top of the shielding front walls so that the manipulators can be removed by taking them upwards.

The total weight of the shielding is 50 tons. This weight implies the necessity of a stable ground. It had to be reinforced by deep concrete injections. Additionally the floor had to be levelled, so that the doors of the cells (weight approx. 5 tons) can be moved with sufficient ease. Therefore steel plates were adjusted on the floor and sealed (see Fig. 2).

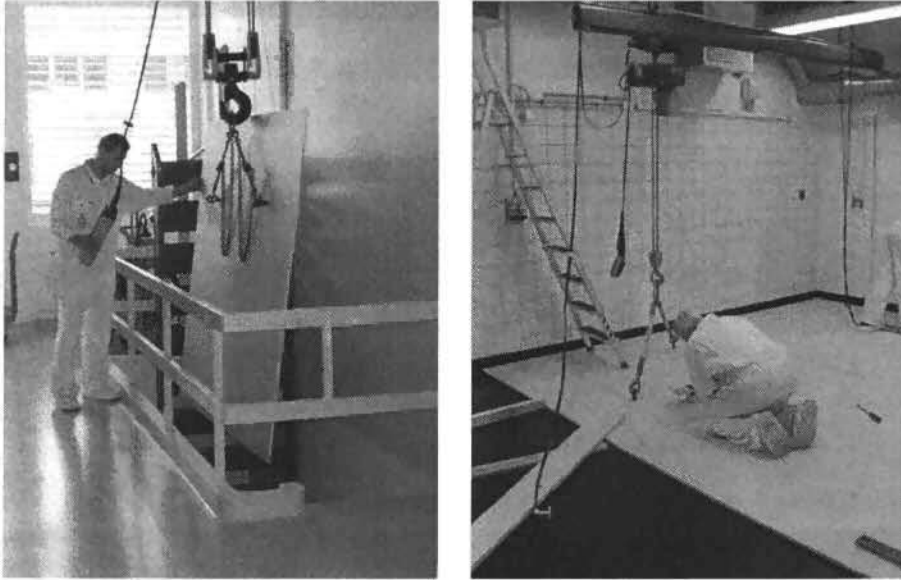


Fig. 2 Transport of steel plates downwards into the basement, assembling on the lab floor and levelling

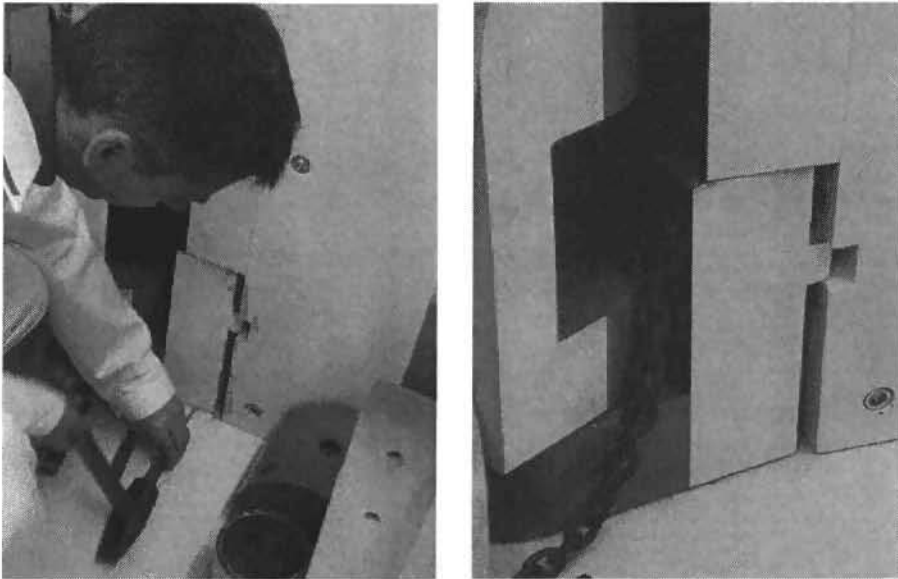


Fig. 3 Assembling door pieces, hinge weight 500 kg ("heavy precision 3D puzzle")

The shielding is composed of very many pieces: For instance, a single door consists of 54 parts; the biggest part of the shielding has a weight of approx. 1000 kg. The weight of the pieces, the lack of space and the transport of the pieces downwards to the labs in the basement required sophisticated logistics and work (Figs. 2 – 4).

All cells are equipped with electricity, cooling water, pressurized air, argon and nitrogen. Fig. 5 shows the first mounted manipulators and the first machine installed in the cell. For the smooth flow of sample transfer the interaction between manipulators, drawers and transport bottle must be tested.

A principal approval by the authorities could be reached. After minor administrative changes, tests with active samples can be started. The first active tests are planned for September/October '04.

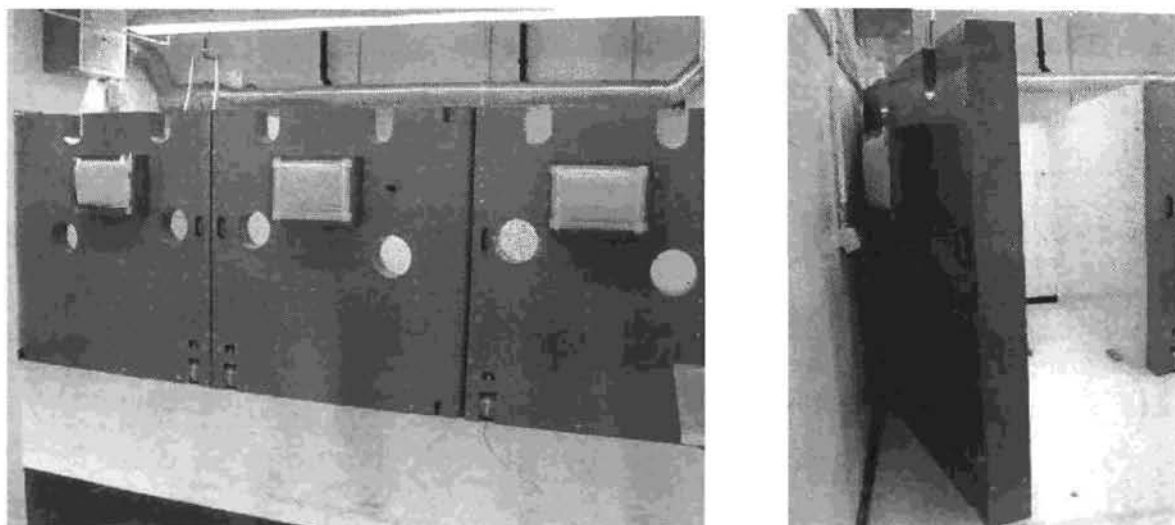


Fig. 4 Overview over the finished shielding and an impression of its fit in the room

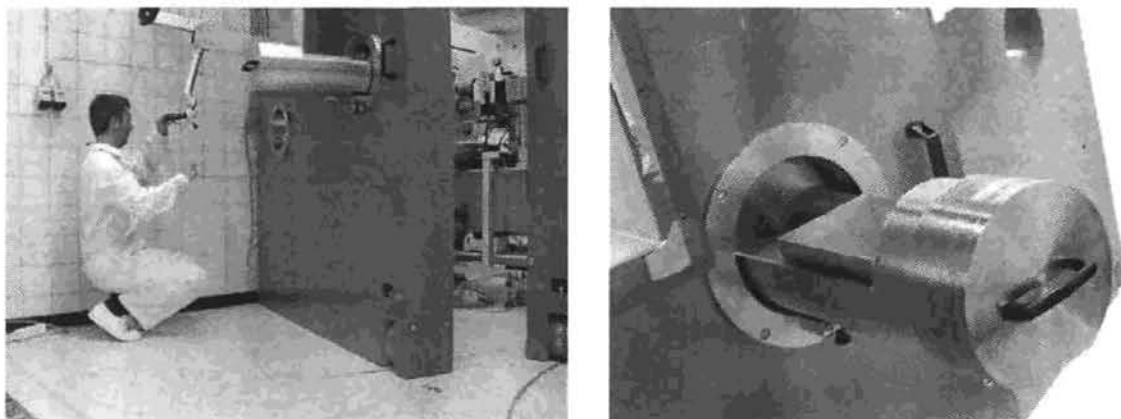


Fig. 5 First machine in a cell, testing of manipulator and drawer interaction

$\alpha\beta\gamma$ -box and tensile testing machine

In a second lab a heavily shielded $\alpha\beta\gamma$ -box will be installed. In principle the conditions are the same as for the $\beta\gamma$ -shielding. This means that the ground must be reinforced by concrete injections. Also the levelling and sealing of a steel plate floor is foreseen. The $\beta\gamma$ -shielding around the α -box is equipped with doors which can be opened. In the case of low doserates the α -box is then directly accessible and even smaller work can be done in the box by utilizing the mounted gloves.

The integration of the testing machine and the furnace is designed taking into account an easy decommissioning at the end of the installation's life. The housing of the furnace is part of the inner α -box. The testing machine is completely outside the α -box but inside the $\beta\gamma$ -shielding. The pulling rods reach via bellows into the furnace.

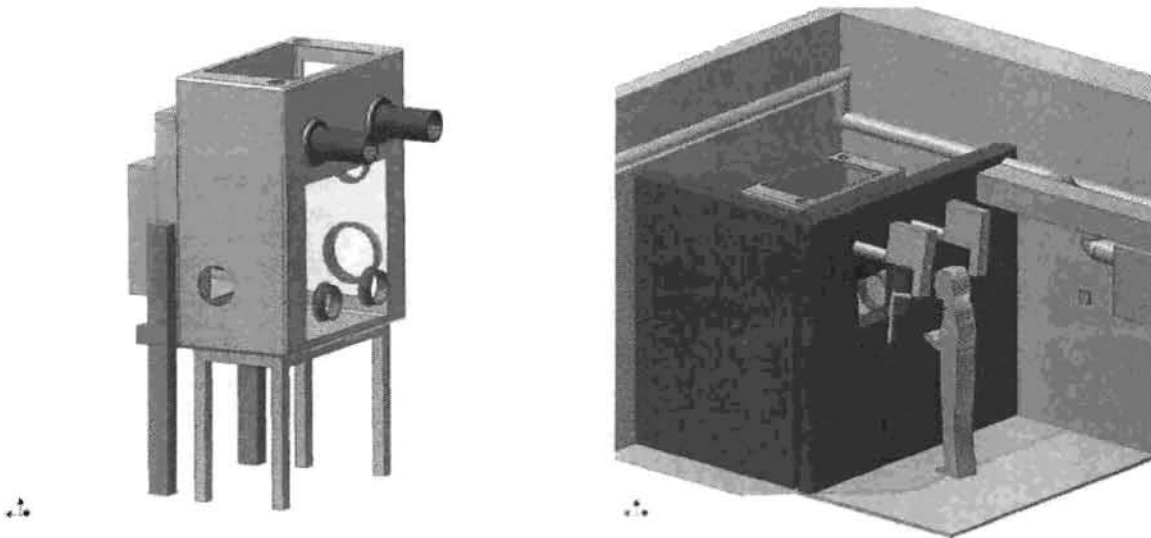


Fig. 6 "Backpack"-solution for furnace being part of the α -box, overview over the assembly

Summary and outlook

At PSI hotlab a concept for versatile mechanical testing of active material was developed. It comprises 2 testing labs and 1 sample preparation lab.

- The $\beta\gamma$ -shielding in the first lab – consisting of 3 cells – is erected, 2 machines are moved into the cells. The third machine will follow in October '04. The first active tests are planned for September/October '04. As the cells are equipped with doors the shift of machines is possible and already foreseen for the mid future.
- The concept for an $\alpha\beta\gamma$ -box in a second lab is designed and a tensile testing machine including a furnace has been ordered. The box will be operable probably in the first half of 2005.
- The concept of a combined heavily shielded $\alpha\beta\gamma$ -box connected with an α -glovebox for sample preparation will be done until September '04. The lab will be operable in 2005.

The concept of the versatile mechanical testing of active materials fulfills the requirements of different working groups at PSI and fits into PSI's philosophy as a user lab.