

HOT CELL FACILITY IN RESEARCH CENTRE REZ, TEST OF BIOLOGICAL SHIELDING AND COMMISSIONING

O. SRBA, P. SVRCULA, T. ADAMIKOVA

Structural and System Diagnostics, Research Centre Rez Ltd., Rez, Czech Republic

ABSTRACT

Paper presents the continuation of construction of hot cell facility within the project SUSEN (Sustainable Energy) at CVR (Research centre Rez). The project uses existing building converted for the purpose of placement of new hot cells. Within this project a new complex of 10 hot cells and one semi-hot cell. Our facility allows work with radioactive samples with activity up to 300 TBq ^{60}Co and with dimension of 2 CT.

Paper is focused on results of test of biological shielding of hot cells with high active source. The purpose of this test was to demonstrate that the biological shielding of the hot cells has the desired efficiency and the measured values at selected points correspond to the contractual values, which were mandatory for supplier of biological shielding. The results are also used as a proof of the optimization of radiation protection for the State Office for Nuclear Safety. Additional information are presented - namely: installation of technologies in hot cells, non-active testing, commissioning and acquirement for authority approval. The project SUSEN is fully funded by the European Union. Most components must be purchased on the basis of competitive tendering or competitive dialogue.

1. Introduction

Within this project a new complex of 10 hot cells and one semi-hot cell will be build. Hot-cells are divided to 8 gamma hot cells and 2 alpha hot cells. The hot cells and semi hot cell will be equipped with experimental devices for diagnostics as well as set of devices for admittance of radioactive samples entering the hot cells (measuring of activity, dimensions, weight), technologies for a complex sample processing (cutting, welding, machining) and set of equipment for carrying out mechanical tests (stress testing machine, fatigue machine, creep, etc.) as well as to study material microstructure (microhardness and nanohardness tester, scanning electron microscope). Our facility allows work with radioactive samples with activity up to 300 TBq ^{60}Co and with dimension of samples up to 2CT.

2. Test of Biological Shielding

Biological shielding of hot cells and transfer pool is designed for work with samples of activity up to 300 TBq of ^{60}Co . Biological shielding of semi-hot cell is designed for activity up to 250 GBq of ^{60}Co . Thickness of the shielding was based on predicted workplace time t_0 , which is the presence of an operator relative to its total working time. Controlled area was divided in 3 groups (tab. 1). Dose equivalent rate was calculated by MCNPX (tab. 2). ^{60}Co source with activity 300 TBq was used as a reference source of gamma ray during calculations. Isotropic source emits two photons with energies 1,173 MeV and 1,332 MeV in one decay. The point source is considered in the calculations.

Workplace	t_0 - the presence of an operator relative to its total working time
Permanent	$20\% < t_0 \leq 100\%$
Temporary	$1\% < t_0 \leq 20\%$
Occasionally	$t_0 \leq 1\%$

Tab. 1 Partition of area

Area	Workplace	Thickness of the shielding [cm]	DER with source inside hot cell [mSv]
Under hot cells	Occasionally	30	2950
Operator room	Permanent	50	1,38
Adjacent box	Occasionally	30 up to 50	2500
Ceiling of hot cells	Temporary	40	20,5

Tab. 2 Calculation of DER

2.1 Composition of Shielding part

All shielding (fig. 1) is made from a stainless steel, the outer wall shielding has thickness of 500 mm, internal wall between hot cells 300 mm with the possibility to make it wider up to 500 mm. The ceiling shielding has thickness of 400 mm and the floor shielding of hot cells is 300 mm wide. The detail design of the shielding has been decided by the supplier of the shielding. All modules are made from steel plates (100 mm wide), outer wall have 5 steps to prevent the gamma ray shots through the shielding (fig 1).

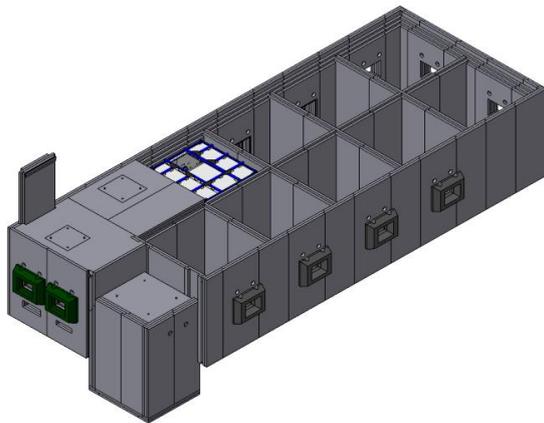


Fig. 1 Layout of the hot cells, left models – model (left), reality (right)

2.2 Preparations for active source

The test was done in joint cooperation of companies Research center Rez s.r.o., Chemcomex a.s. and VF a.s.. The Contractor ensured the necessary permits, high active source and transportation container. For this test several prototype equipment's were manufactured. MCNP calculations were made for determine dose rate equivalent (tab. 2). Risk analysis showed some potentially dangerous operations. All these operations were backed up, some twice. Non-active test were performed for training of crew and to proof that the place is ready (fig. 3). The tests was carried out with closed radiation source, so we didn't need active ventilation. Critical points were pre-selected, and measuring points were detailed planned (fig. 2). Points for hot cells were measured for each cell.

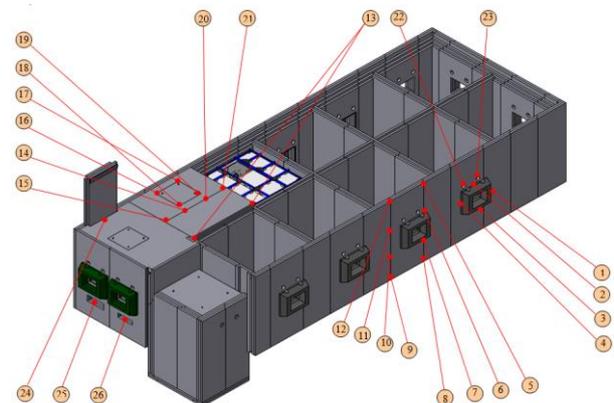


Fig. 2 Measuring points

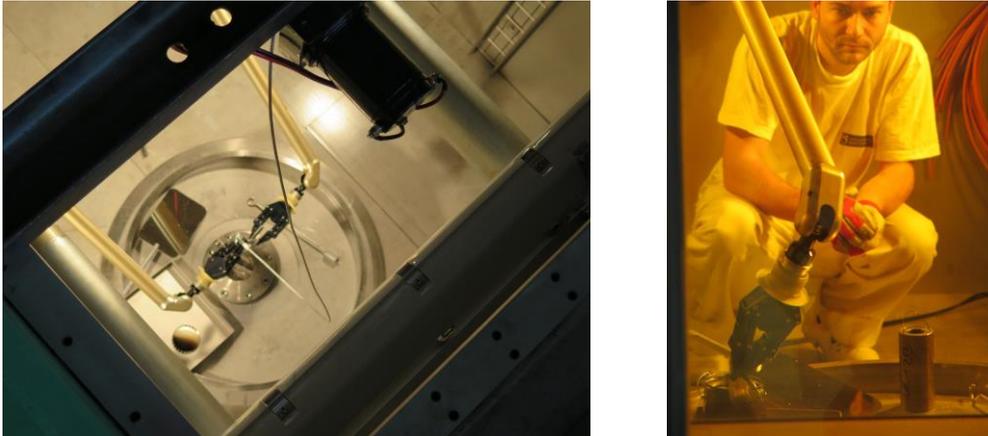


Fig. 3 Preparation (left) and training (right)

2.3 Testing process

One hermetic box has been completed and equipped with cameras, radiation probe, lights and other support utility. The container with source was inserted in this box. Inside shielding and Box all manipulation with source was done. Then the whole box was shifted between the individual cells and reconnected (fig. 4). This proves that the Box is interchangeable. Time schedule was for 7 day (12 hours per day) with some time reserve, in reality everything was done in 4 days thanks to Box system.



Fig. 4 Changing position



Fig. 5 Contamination control (left), manipulation with source (right)

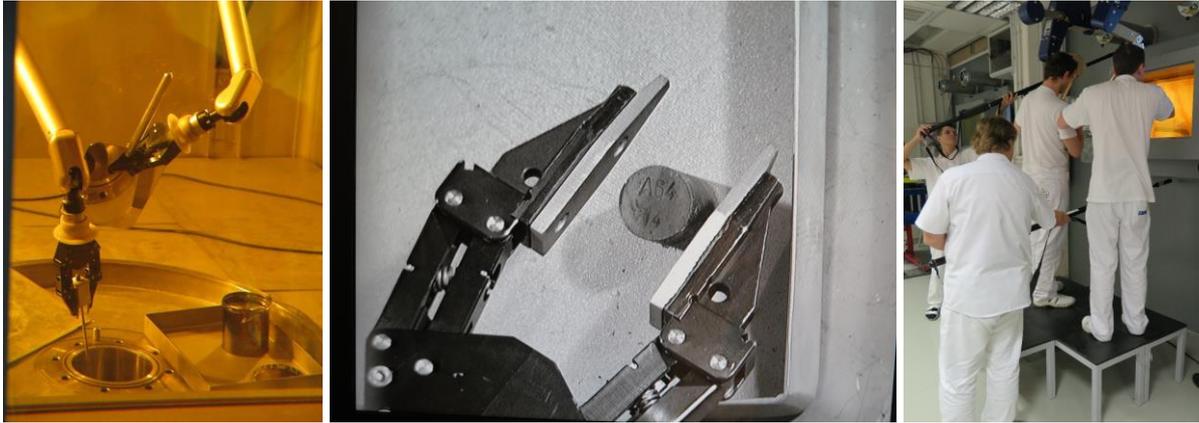


Fig. 6 Operations (left), source (middle), measuring (right)

2.4 Results calculation/reality

The test proved the propriety of biological shielding. No gamma ray shot were detected. It was discovered few hot spots, where dose equivalent rate reached up to $2.8 \mu\text{Sv/h}$. These veluse are directly on the surface of the shielding. However, this value was in the range of agreement. The test was evaluated as successful (tab. 2). The doses received by the staff during the test, were very low. The doses were in the range from 2 up to $6 \mu\text{Sv}$. Measurements showed that the shielding ability of the complex of hot cells is fully comply with the requirements of radiation protection at the workplace of III. category according to the Atomic law.

Measured point	Hot cell – 300 TBq [mSv/h]		Semi – hot cell – 60 GBq (Extrapolated for 250 GBq) [mSv/h]
	Calculated	Measured	Measured
Operator room	1,4	0,4	0,8
Under operator room	4,2	18	2
Under hot cell	118	300	12
On the ceiling of hot cell	54	14,3	2,5

Tab. 2 Measure values

3. Last support technologies

Most infrastructure are in place and tested. Some part are just being install. Most important is transportation device. Detail design is finished and some parts are already install (fig. 7). In the end of this year shielding properties will be tested.

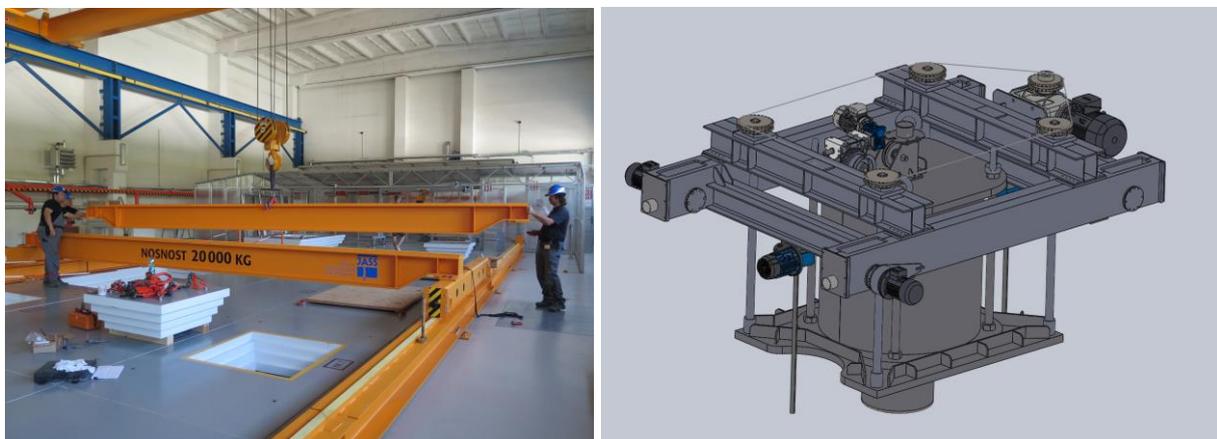


Fig. 7 Motion part of transportation device (left), detail design of cask (right)

4. Installation of technologies in hot cells

Each instrumentation was tested firstly inside hermetic Box and then after some practise everything was moved inside chamber. That allowed to shorten the time necessary for the whole project to finish. All connection to the box and instrumentation were made as projected. The holes necessary for connection were shielded by movable lead drawers and the wires and pipes are guided around.

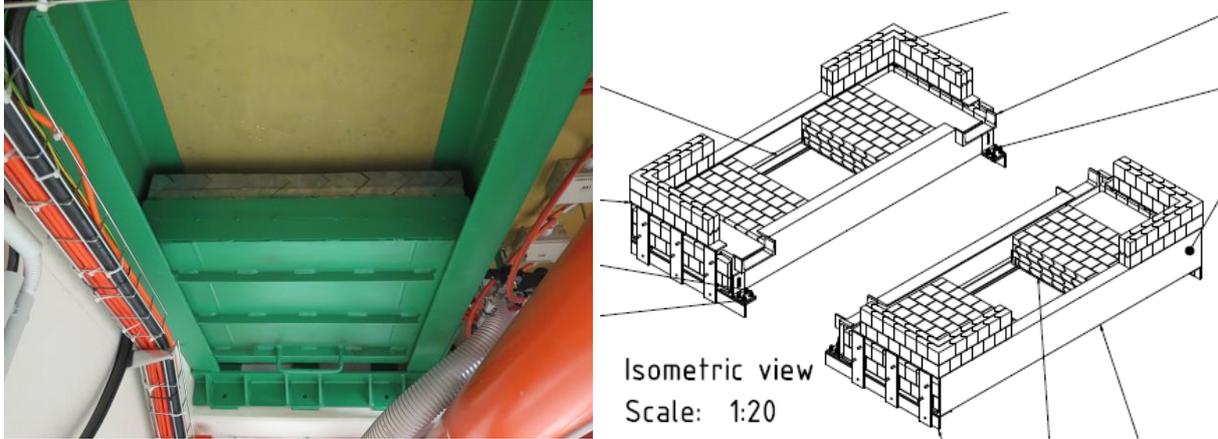


Fig. 8 Shielding of connections



Fig. 9 Interconnection



Fig 10 Received instrumentation

5. Non-active testing

After installation by producer each chamber were prepared for radioactive testing. After that non-active testing started. Each chamber has to be equipped with instrumentation that allowed remote handling of all kind of testing samples. These equipment has to be modify for

our special condition (removable box). All systems (autonomous and manual) are being tested and debugged (control system, rad. monitoring system, active ventilation).



Fig. 11 CNC in docking bay



Fig. 12 Electro-discharge cutting machine



Fig. 13 Tensile machine

6. Next step

In the end of this year the facility will receive approval from authorities and active testing process will start. It will be done by low-active materials. All systems (principles, decontamination, all procedures) will be tested from security point of view. Monitoring systems and decontamination procedures will be improved based on contamination spreading. First active measuring is scheduled at the end of 2017.

7. Conclusions

Hot cells complex is ready and will be tested on active materials in year 2017. New facility is full of new ideas and approaches that has to be proved and tested. The whole system will cover all process: receiving of the material, samples preparing, mechanical testing and microstructure observation. Our hot cells are close to research nuclear reactor LVR-15 and new irradiation facility (high irradiation by cobalt source in high and low temperatures also vacuum) which will be built in project SUSEN. This allowed us to cover everything for R&D of materials for Gen II NPP, future NPP Gen IV, fusion reactors and space programs.

8. Acknowledgments

The presented work was financially supported by the Ministry of Education, Youth and Sport Czech Republic Project LQ1603 (Research for SUSEN). This work has been realized within the SUSEN Project (established in the framework of the European Regional Development Fund (ERDF) in project CZ.1.05/2.1.00/03.0108).

9. Nomenclature

Hot cells, active samples testing, radiation protection.

10. References

[1] <http://cvrez.cz>

[2] <http://susen2020.cz>