5.5

INSTITUTE of ATOMIC ENERGY

MATERIALS RESEARCH LABORATORY

phone/fax: (48 22) 779 86 63
05-400 Otwock-Świerk

FACILITIES FOR TESTING RADIOACTIVE MATERIALS AT THE INSTITUTE OF ATOMIC ENERGY IN POLAND

Waldemar Bilous, Ewa Hajewska, Witold Szteke, Tadeusz Wagner

1. Material Research Laboratory - general informations

Institute of Atomic Energy is located in Świerk near Warsaw. The structure of the Institute consists from 21 research teams, 3 laboratories, Research Reactor Centre, Radioactive Waste Management Department and CYFRONET Computing Centre. Material Research Laboratory was formed in 1994 from 3 research teams: Materials Investigation, Technology & Special Techniques, Radiation Damage and 1 laboratory - Hot Laboratory.

All work in Material Research Laboratory is carried out according to the Quality Assurance Programme. MRL has the Certificate of Testing Laboratory Accreditation Nr L 21/1/95. This is to certify that Material Research Laboratory in the Institute of Atomic Energy is in conformance with the standard PN-EN 45001 and ISO/IEC Guide 25:1990. Material Research Laboratory has been also granted 2-nd Degree Approval according to the specifications of the Office of Technical Inspection DT-L/95. The approval is registered under number L-II-001/27.

Material Research Laboratory is divided to 6 sections:
- Section 1 - Structure and Corrosion Investigation,
- Section 2 - Mechanical Properties Studies,
- Section 3 - Physical Properties Measurement and Specimens Working,
- Section 4 - Irradiated Materials Investigation Service,
- Section 5 - Quality Assurance,
- Section 6 - Technical and Economical Service.

In **Section 1** we perform the experts opinion and reatestation testing of structural materials and its welded joints on:
- chemical composition of metals and its alloys using spectral methods,
- structure investigation using light microscopy, transmission and scanning electron microscopy as well as X-Ray diffraction methods,
- corrosion studies of metals, in this: intergranular corrosion of stainless steels tests, stress corrosion cracking and corrosion in autoclaves.

The influence of the heat treatment and cold plastic deformation on the precipitation processes of the secondary phases in different kinds of materials is also studied. X-Ray diffraction method is used for the structure investigation of metals and of concrete as well as for metal texture examination.

In **Section 2** the experts opinion and reatestation of mechanical properties are perform.

Opportunity is provided for the studies of mechanical properties of metals at room, elevated and lowered temperatures, hardness measurements, determination of creep resistance, low-cycle fatigue strength and crack fracture toughness of metals. The correlation between the residual life of structural materials and crack fracture toughness factors in static and dynamic conditions is also study.

Section 3 performe the measurement of density of metals, before and after irradiation, as well as the heat treatment of irradiated specimences.

The other activity of this section is the specimens making in the work-shop according to the standards and Quality Assurance Programme prescription.

Section 4 is responsible for the maintenance of the hot laboratory in good state, according to the Quality Assurance and Nuclear Safety prescription.

Section 5 is responsible for the preparation of quality assurance documents as well as for their correct application in all work. This section execute also the internal audits in the laboratory.

Section 6 is responsible for the maintenance of all equipment in a good state, for the purchases of materials and equipment and solve all economical and technical problems in MRL.

2. Hot laboratory

The hot laboratory at the Institute of Atomic Energy in Świerk was finished in 1993. It was destinated for testing the suirveillance specimens from planned nuclear power station. In 1992 the construction of power station in Żarnowiec was stopped and in the laboratory we investigate only irradiated materials from research reactors EWA and MARIA and from the Central Repository of Radioactive Waste.

The hot laboratory consists of the assembly of 12 lead hot cells arranged in line (Fig.1). All cells were designed to handle 3700 GBq (100Ci) of 1MeV gamma emitter. Each of the cell is equipped with a viewing window and with a master-slave or tongs manipulators. The hot cells are connected with one another by special innert transport system. The assembly of hot cells are equipped with a ventilating, active wastes and dosimetric systems.

Destination of the individual cell is as follow:

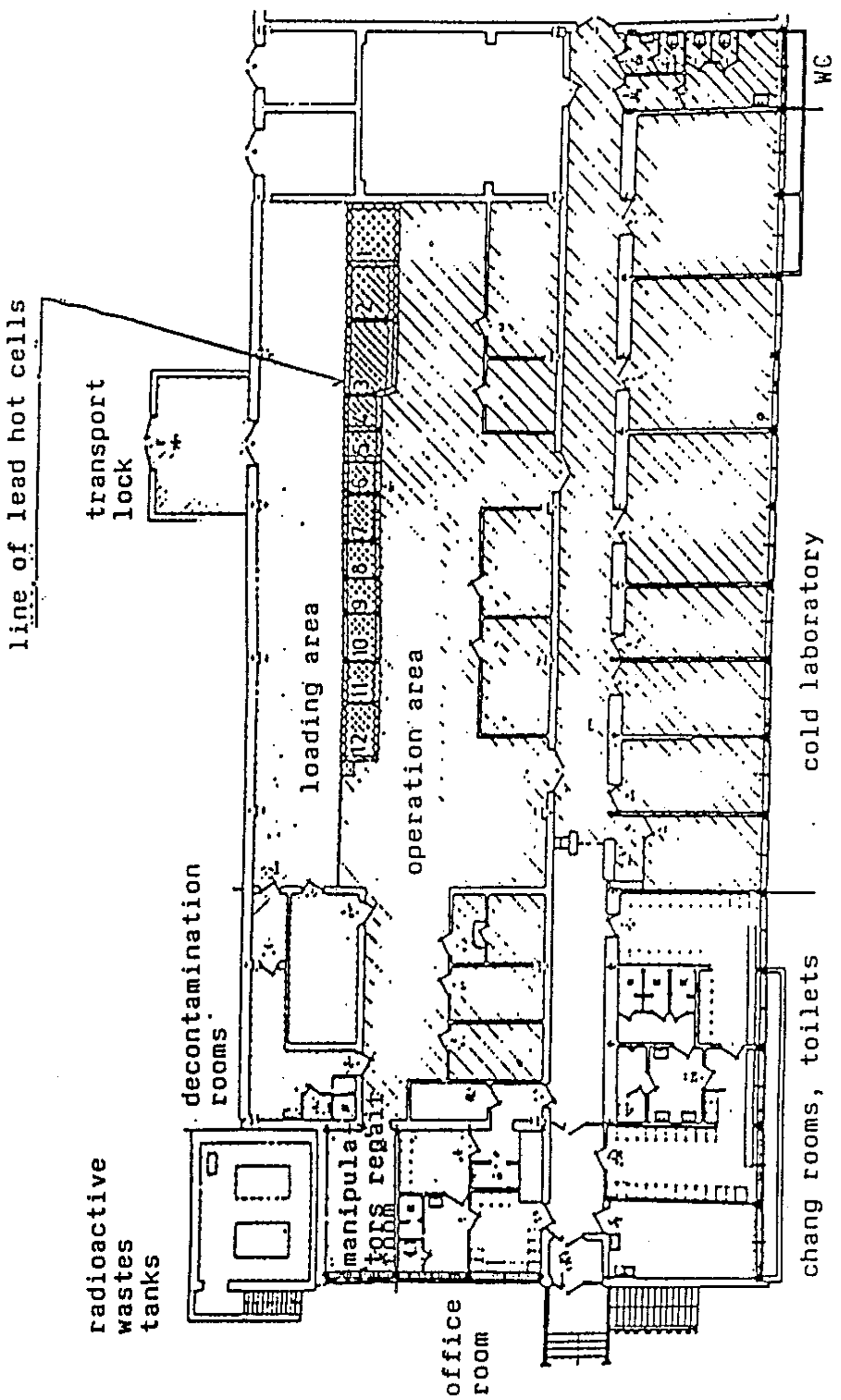
Cell 1 - Structural Rőntgenography

X-Ray diffractometer DRD-4 type is used for structural X-Ray analysis of irradiated materials, phase identification, texture examination and lattice constant measurements.

Cell 2 - Technological operations

Cell is destinated for unloading of the cascks with active materials, cutting out and marking of the samples. Cutting machine is equipped with cut-up wheel wet and dry type.

GENERAL PLAN OF HOT LABORATORY



Cell 3 - Preparation of specimens for metallographic and X-Ray examination
The work programme comprise the full range of operations connected with preparation of specimens for microscopic investigations, in this: mounting of specimens, grinding and mechanical as well as electrochemical polishing and etching, macrophotography of mounted specimens. The thin foils and replics for transmission electron microscope and preparations for X-Ray tests were also prepare in this cell.

Cell 4 - Light microscope
TELATOM - Reichert light microscope destinated for observation, photography and microhardness measurements is installed in the cell.

Cell 5 - Unloading and samples storage
Cell is equipped with the transfer lock for unloading of transport containers with irradiated materials. The storage for 130 specimens is mounted in the upper part of the cell.

Cell 6 - Physical properties measurements
Test stand for density of irradiated specimens determination using special balance SARTORIUS type is placed in this cell.

Cell 7 - Chemical analysis
Chemical analysis using classic methods can be carried out in this cell.

Cell 8 - Heat treatment
Two special furnaces for heat treatment of irradiated specimens at the temperature range from 20°C to 1200°C are located in this cell. The annealing of radiation damages in irradiated specimens will be carried out using this equipment.

Cell 9 - Hardness testing
For hardness measurements the remptely operated WOLPERT hardness tester DIA-TESTOR 7521 will be used.

Cell 10 - Strength testing
The INSTRON 8501 servohydraulic testing system with new full digital control is used for testing of irradiated specimens. Equipment allows to carry out the following tests at temperature range from -150°C to 350°C:

- proof stress,
- low cycle fatigue,
- K_{IC},
- J_{IC} unloading compliance method,
- da/dN crack propagation,
- CTOD.

Cell 11 - Without equipment

Cell 12 - Impact strength tests
For impact tests of irradiated Charpy type specimens the remotely operated instrumented WOLPERT pendulum impact testing machine PW 30/15 is used. The experiments can be carried out at the temperature range from -50°C to 900°C for determination:

- significant force and deflection values,
- partial energy values,
- characteristical fracture-mechanical values according to ASTM E 24.03.03 - K_{ID}.

3. The main works carried out in the hot cells

Besides of the experts opinions for the research reactor placed in the Istitute of Atomic Energy in Świerk, following works were carried out:

3.1. Aluminium and its alloys investigation

Auminium and its alloys are used as a structural materials in the research reactor. The specimens of aluminium grade A1 and its alloys with magnesium and silicium, irradiated in the fluences range from $1\times10^{19}n/cm^2$ up to $1,4\times10^{22}n/cm^2$ were examined.

Aluminium grade A1 is a technical one, PAR-1 (SAW-1) belongs to the group of Al-Mg-Si alloys intended for further plastic work. The content of Mg various from 0,6% to 0,8% and the content of Si from 0,8% to 1,2%, in the PA-2 alloy the content of Mg is about 2%.

The structure and mechanical properties of all this materials before and after irradiation were tested. The influence of the heat treatment and cold plastic deformation were also studying.

3.2. Reconstruction of the Charpy type specimens after irradiation

From 1995 we started to elaborate technology of reconstruction of Charpy type specimens after irradiation. Till now we have choosen the technology of welding for the reconstruction of the specimens made in low-alloy steels.

In the nearest future we are going to install the stand in the hot cell and to adapt it for remotaly operation. We hope to finish this work up to the end of 1996.

3.3. Welding of the containers with the radioactive wastes

The cell nr.3 was instrumented with the equipment for special programme of safe storage of radioactive wastes. The containers with radioactive wastes made in stainless steel are welded. The TIG welding method is used for sealing stainless steel capsules containing used radioactive sources as Ir^{192} and Co^{60}.

3.4. Studies of the influence of external factors on degradation of concrete properties using structural methods

Institute of Atomic Energy is the owner of the Central Repository of Radioactive Waste. The state of the concrete taken from the oldest drum disposed in CRRW was compared with new concrete in order to evaluate degradation extent. The fracture of 30-years old concrete from CRRW and new one were observed and documented by means of scanning electron microscopy and using X-Ray diffraction method.

4. Summary

At present the most part of research work in Material Research Laboratory is carried out in non-irradiated conditions. Some work for our research reactors as well as for the Central Repository of Radioactive Waste is also carried out with the irradiated materials.

In the nearest future we will start to the material programme connected with the decommissioning of research reactor EWA and to the radioactive waste and spent fuel management programme. The first programme include the examination of aluminium alloys irradiated with the fluences up to $5\times10^{26}n/cm^2$ and the second examination of the fuel element cladding as well as the structural material of the spent container for fuel elements.