MEASUREMENT IN NUCLEAR ENVIRONMENT

ADAPTATION OF STANDARD THERMAL ANALYZERS AND CALORIMETERS TO NUCLEAR ENVIRONMENTS

The study of radioactive materials science requires the handling of hazardous substances (fuels, wastes, reactive gases, etc.) under safe conditions for both the operators and the instruments that are used for characterization studies. In many cases, these materials need to be handled in glove boxes or in hot cells (lead chambers) depending on the radiation types and intensities.

Thermal analysis and calorimetry are common thermal characterization techniques for nuclear fuels (current or candidates), wastes, and surrounding materials (ex: cladding). The instruments being used must be customized to be compatible with these specific operating conditions.

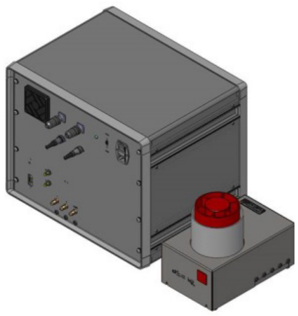
KEY ELEMENTS

Setaram specializes in customized instrument design, has an expertise in electronics, and our R&D team is structured to be able to manage specific projects, which has allowed us to work in this field for a long time. One major issue is to separate the thermal analyser elements such as the furnace, the sample chamber and containers, the measuring modules, etc. which must be placed in a glove box or a hot cell, from the control and acquisition electronics.

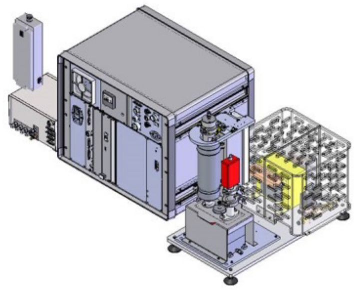
These are kept outside the glove box of hot cell because of their low resistance to irradiation and also to help with ease of maintenance of the instrument. Once designed and manufactured, the unit also needs to be installed by our qualified personnel, accredited to operate in nuclear environments.

TECHNICAL ACHIEVEMENTS

High temperature TGA, TG-DTA/DSC (for corrosion, stability, stoichiometry studies, long-duration isothermal reactivity of oxides), high temperature calorimeters (drop or heat flow methods for heat capacity and phase diagram determinations) or lower temperature Calvet calorimeters (for thermal activity of wastes, heats of reaction) have already been successfully customized to fit these specific conditions. See the pictures below.



DSC131 Evo: The electronic circuitry (left) is installed in a separate remote box to avoid its exposition to radiation.



«Customized» LABSYS TGA to be placed in a glovebox

High temperature calorimeter placed in a glovebox (reproduced from [1])

[1] O. Beneš and al, J. Chem. Thermodynamics 43 (2011) 651–655

MEASUREMENT IN NUCLEAR ENVIRONMENT

GOING FURTHER

There are applications outside the nuclear field for these customized instruments. Some examples include testing toxic materials, running tests involving flammable or explosive gases, or when contact with air may affect the integrity of the material being tested.

In a few cases, the instruments need to be completely redesigned to be installed in existing glove boxes or hot cells and then assembled inside by operators guided by our engineers and technicians.

CONTEXT

A widely renowned institute in the field of nuclear research consulted SETARAM Instrumentation to design, manufacture and deliver a thermobalance to be placed in an existing glovebox. It was part of a glovebox setup dedicated to the preparation and characterization of actinide based samples.

The inside dimensions of the glovebox were of course fixed. Since it was not possible to open the glovebox, assembling the thermobalance parts also had to be done on site by operators who where guided by our engineers and technicians. Moreover, all of the parts had to be transferred using containers with challenging maximum dimensions (diameter 250mm and height 380-800mm) and challenging maximum loading capacities (5 or 25kg depending on the container).

Other constraints of the system included a temperature constraint which impacted the thermobalance (the maximum outside temperature was 50 °C), the electronic circuitry, which had to be separate from the rest of the system, and the fact that the thermobalance needed to be on an earthquake-resistant frame.

A number of control tests from the client were scheduled during the design and manufacturing process, with factory acceptance and on-site acceptance tests.

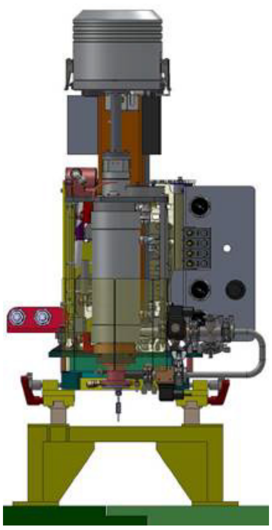
TECHNICAL ACHIEVEMENTS

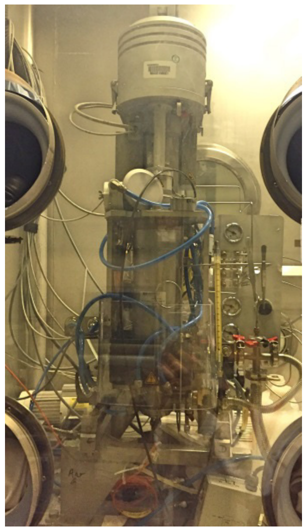
The electronic circuitry was installed in a separate box connected to the thermobalance by a cable feedthrough system. It saved space in the glovebox and decreased the amount of irradiated wastes.

All of the bulky parts were redesigned, including the thermobalance platform and furnace power supply transformer in order for them to fit into the dimensions of the transfer container.

The thermobalance was placed on an articulated frame in order to access to any part of the instrument, and a number of mounting parts have been redesigned: handles were added to ease the operation of the different heavy or bulky parts, which helped to make maintenance easier. Moreover, sharp parts or edges were modified to avoid ruining gloves.

The furnace cooling system was changed to include a double loop system with a primary circuit and a heat exchanger inside the glovebox, and a secondary circuit outside the glovebox with quick fit connections.





CAD schematics (left) and thermobalance installed in the glovebox (right)

SETARAM Instrumentation KEP Technologies
sales@setaram.com
www.setaram.com