Adaptation of standard thermal analyzers and calorimeters to nuclear environments

INTRODUCTION

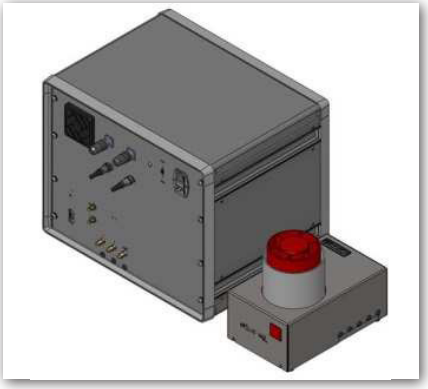
The study of radioactive materials requires handling of hazardous substances (fuels, wastes, reactive gases, etc.) under safe conditions for both the operators and the instruments that are used for characterization studies. In many cases, these materials need to be handled in glove boxes or in hot cells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

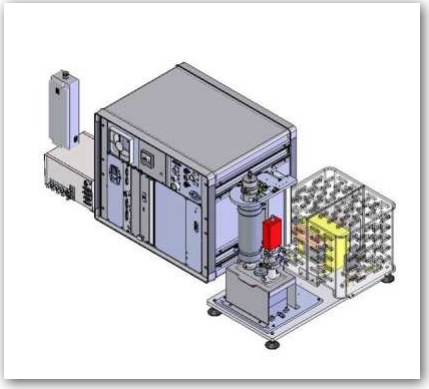
Setaram specializes in customized instrument design, has an expertise in electronics, and our R&D team is structured to be able to manage specific projects, which has allowed us to work in this field for a long time. One major issue is to separate the thermal analyser elements such as the furnace, the 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 calorimeters (for thermal activity of wastes, heats of reaction) have already been successfully customized to fit these specific conditions. See the pictures below.



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



"Customized" TGA to be placed in a glovebox

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

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.

For a more detailed example of adaptation, see technical note TN729.

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