APPLICATION OF THE IN-SITU GAMMA SPECTROSCOPY BY WESTINGHOUSE ELECTRIC GERMANY

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1 Introduction

In the course of the last ten years the in-situ gamma spectroscopy has become an inherent part of nuclear instrumentation. It is nowadays applied, by default, in operating nuclear power plants as well as increasingly used in decommissioning nuclear installations. Typical fields of application of the in-situ gamma spectroscopy are:

- determination of radioactive deposits in pipes and components of operating nuclear power plants
- measurements for clearance, e.g. of building structures and soil, in the frame of decommissioning nuclear installations
- checking of decontamination actions, measurement of waste packages

The performance and equipment of measuring systems applied for this purpose are based upon the respective use and the state of the art valid at the time of the purchase.

2 Performed in-situ measurements

Today's Westinghouse Electric Germany (WEG) performed its first gamma spectroscopic in-situ measurements by 1980 in the frame of a research project for the reduction of radiation exposure of the personnel of nuclear power plants.
Since 1984 we have performed measurements on behalf of operators and authorities. These measurements include:

- about 60 measurements at cooling pipes of 10 German and 2 Swiss nuclear power plants all in all
- about 30 measurements at pipes and components of the auxiliary and secondary systems of the reactor coolant system as well as at the steam generator
- measurements in connection with the decommissioning of the uranium plant at Ellweiler
- measurements in order to check the success of decontamination when decontaminating the reactor coolant system of Mülheim-Kärlich NPP.

The measurements on the cooling pipes provide the quantitative nuclide specific determination of the deposits at the inside of the pipes and is therefore essential for the evaluation of the chemical operation mode of the plant. The measurements on further pipes and components act as safeguarding of the overall radioactive situation of the plant or as clarification of a specific circumstance. The measurements in the uranium plant of Ellweiler and in Mülheim-Kärlich are examples of typical applications for special problems.

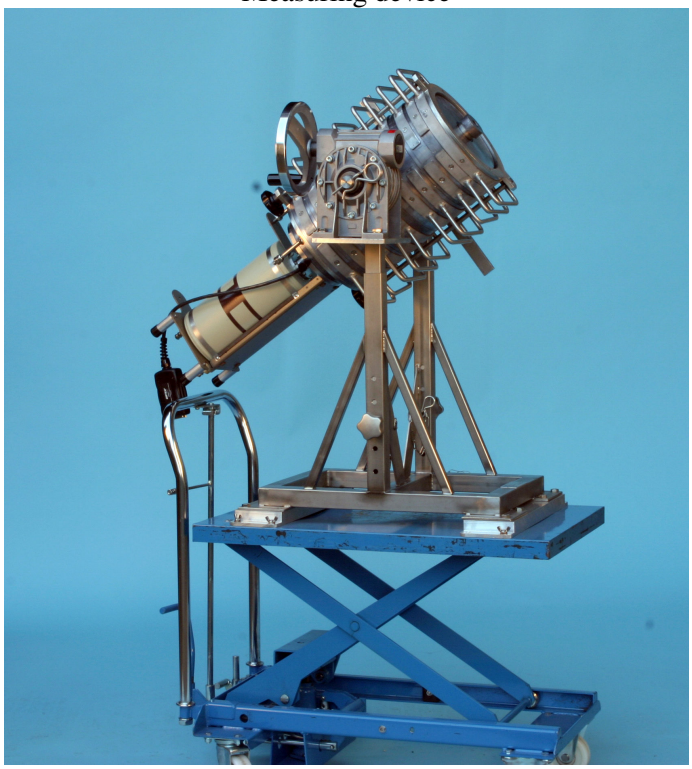
3 Measuring devices

Our measuring devices consist of the following components:

- pure germanium detector, suited for measurements of higher activities
- modules of shielding with various collimators which can be transported and reassembled
- device for mounting and positioning of the shielding
- multi channel analyser, laptop, cabling

The performance of the measurements delivers a minimal radiation exposure since the measurement devices are operated within an area of low local dose rate.

Measuring device



4 Measuring process and evaluation

In a first step deposits are determined by measuring two gamma spectra, the first one with opened collimator (M) and the second one with closed collimator (U) at a typical measuring point of the component.
In a second step the measuring arrangement including the component are processed into a 3D-computational model. By means of this model and a Monte-Carlo-Simulation (MCNPX) the nuclide specific and the geometrical calibration factors are determined.
Since these factors are calculated as well for the measurement with opened collimator (X1) as for that with closed collimator (X0) the impact of background radiation on the measuring results can be established. This is an important point for the evaluation of the accuracy and reliability of the measuring results
The activity of the deposits in Bq/cm² is calculated according to:

$$A = \frac{1}{\varepsilon_E \cdot \varepsilon_A} \cdot \frac{M - U}{X_1 - X_0}$$

with ε_E being the specific emission probability and with ε_A being the detector efficiency.

Westinghouse Electric Germany has experimentally checked the analysis procedure. There is a good congruence of the results established by experiments and by calculation.

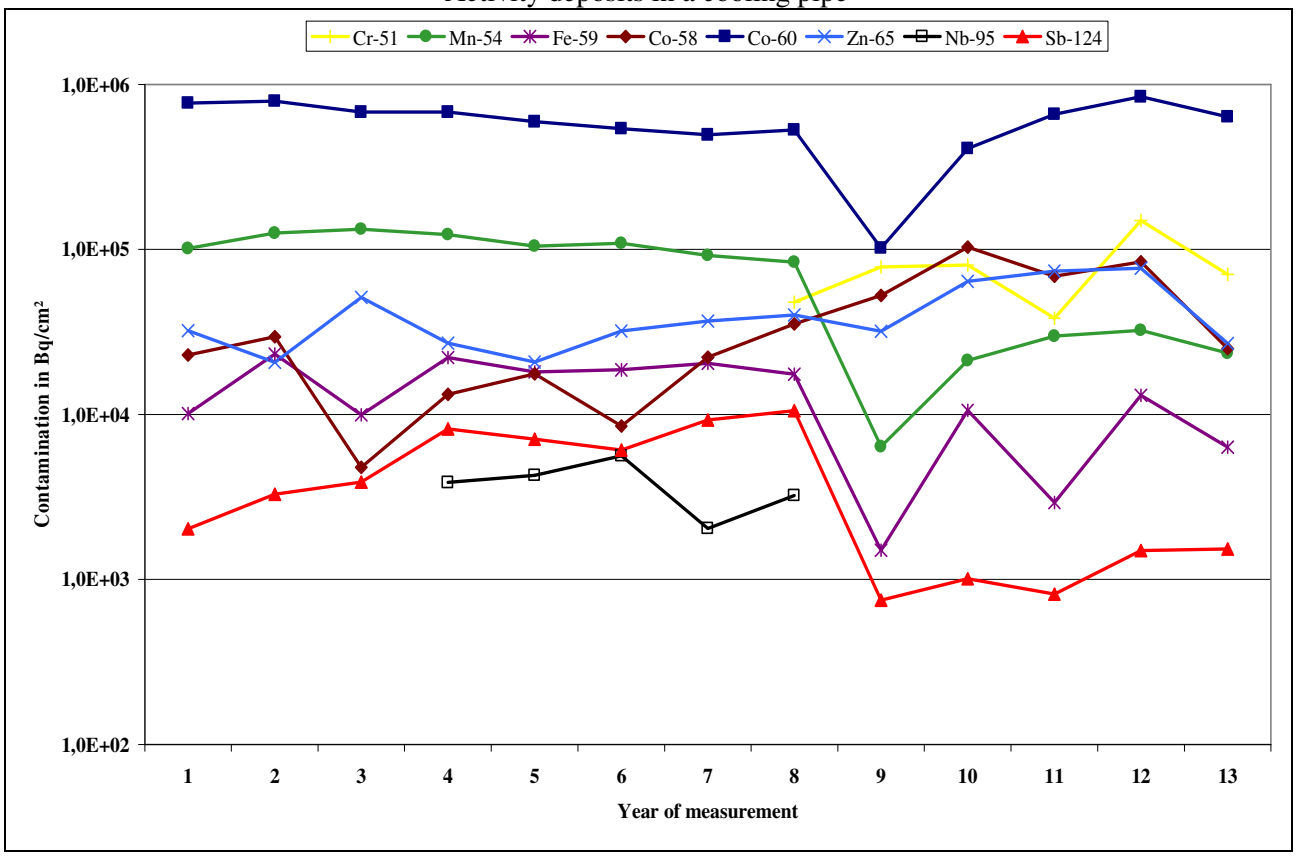
5 Measuring results

5.1 Measurements on cooling pipes

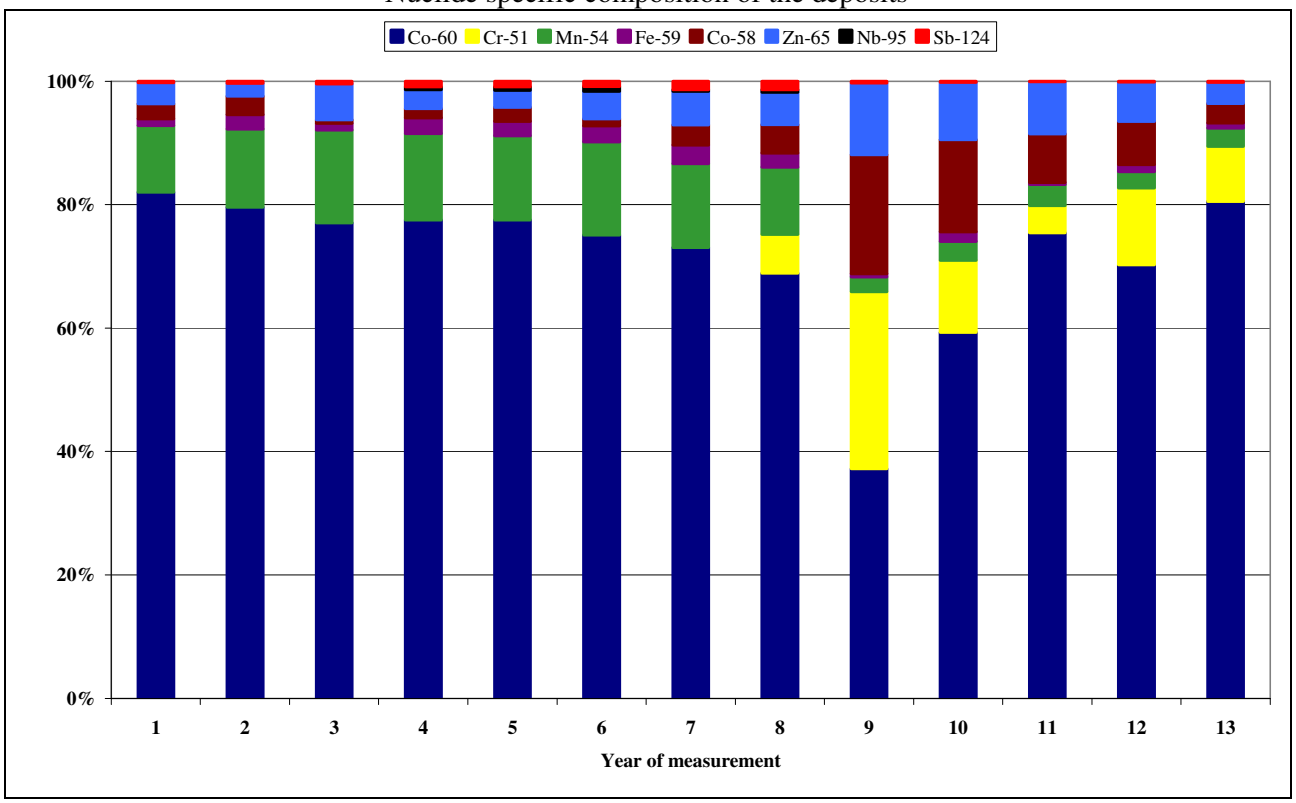
The comparison of the deposits during a longer period of time permits the verification of the chosen water chemistry and the well directed understanding of the efficiency of certain actions, such as the removal of antimony or zinc dosage.

The two following illustrations show the long-time development of the deposits in cooling pipes as well as their nuclide specific composition in percent.

Activity deposits in a cooling pipe



Nuclide specific composition of the deposits



For nearly 15 years we have conducted gamma spectroscopic measurements on the outside recirculation loops in Mühleberg, Switzerland, a plant with boiling water reactor.
Since the start-up our radiochemical laboratory in Baden, Switzerland, has counselled and cared for Mühleberg in the fields of chemistry and radiochemistry. The gamma spectroscopic measurements are an essential supplement for the regular measurements executed by WEG in respect of the radiological state of this plant.

5.2 Further applications

The actual radiological state of the uranium plant of Ellweiler has been recorded in the frame of the decommissioning of it. For this record we conducted a series of gamma spectroscopic measurements for the planning of the appropriate waste management.
In February 2002 WEG conducted a decontamination of the reactor coolant system in the power plant of Mülheim-Kärlich. In order to establish the decontamination factor gamma spectroscopic measurements among other measurements were conducted at different points of the reactor coolant system before and after the decontamination. In combination with model calculations the decontamination factor for the heat-transfer tubes for example was derived from these measurements.
In the course of the 2004 revision of the Neckarwestheim Block I we conducted measurements on two containers with resin ion exchanger stemming from the decontamination of the recuperative heat exchanger in addition to the measurements conducted at the cooling lines. The containers had different dimensions and were shielded by lead.
The nuclide vector calculated by us and the established activity inventory were an important information for the plant to evaluate the decontamination of the heat exchanger.

6 Final remarks, Prospects

From our elaborations you can see that for 20 years the in-situ gamma spectroscopy has become an inherent part in the product range of WEG . During this time we have continually improved our measuring equipment and analysis methods and thus we are able to conduct successfully measurements for standard applications as well as for special applications. This applies for operating plants as well as for the field of decommissioning in which the in-situ gamma spectroscopy increasingly gains in importance.