PRESENT STATUS OF THE MANGANESE SULFATE BATH AT THE LNMRI

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ABSTRACT

At IRD/LNMRI/LN – Laboratório de Nêutrons is used to calibrate isotopic neutron sources the Primary Standard System Manganese Sulfate Bath. Compared with other systems used to measure neutron source emission, this one shows better accuracy and uncertainty. Besides this system has many parameters, like: volume, solution density, electronic system dead time, counting rate, etc. those may be changed, affecting the value of MnSO4 solution saturation activity. This value is used to calculate the neutron source emission rate. In this work, the results of saturation activity during one year of measurements are showed.

Key Words: manganese bath, neutron sources, activity, emission rate.

I. INTRODUCTION

After the start of cooperation program between BIPM – Bureau International de Poids et Mesure, INMETRO – Instituto Nacional de Metrologia, Normalização e Qualidade Industrial and IRD/LNMRI – Laboratório Nacional de Metrologia das Radiações Inonizantes, it was possible to install at LN – Laboratório de Nêutrons, the primary standard system for neutron source calibration, namely Manganese Sulfate Bath. The Manganese Sulfate Bath that was donated by BIPM to arrive in Brazil at LN in 1996. This system is composed by one stainless steel sphere with 1 m of diameter, to fill with concentrate manganese sulfate solution (~524 liters). In the calibration process the neutron source to be calibrated is deep in the sphere. The neutrons emitted by the neutron source are moderated in the solution and captured by the manganese atoms. After an immersion period of 25 hours, the neutron source is removed from the bath, and is replaced by a scintillation detector (NaI(Tl)), to measure the gamma rays from manganese atom decay activated by neutrons from the source. All these measurements, permit us to obtain the neutron source emission rate, with a total uncertainty of 1.4% within confidence level of 2σ.

The uncertainties and the values of saturation activity after one year of measurements will be showed in this work.

II. INSTALLATION AND TESTS

The Manganese Sulfate Bath was installed in a room with 52 m^2 with an air conditioning system, to keep the temperature at 20 ± 1 °C. All the manganese solution was filtered before being put inside the bath using a Millipore filter and a circulating pump. The main difficult during the Manganese Sulfate Bath installation was due to the electrical noise produced by electrical ground reference deficiency. This problem affected our uncertainties when we measured the system dead time, background and manganese decay. During the initial tests we received technical assistance from a NPL expertise. That time was noted that our neutron background was high compared with that of NPL. That is because we had our neutron sources (total of 20 neutron sources) where near from the Manganese Sulfate Bath. That was later solved by constructing a new building only to store neutron sources far from the Manganese Sulfate Bath. Although the problem with neutron background had been solved, we continued to have electrical problem. The solution spent a long time and efforts to make a revision in all electrical lines at LN.

III. METODOLOGY AND DISCUSSION

Fig. 1 shows one picture of Manganese Sulfate Bath setup that is mounted at LN – Laboratório de Nêutrons.

During the measurements were used an AmBe neutron source with 3.7×10^{10} Bq. This neutron source was previously calibrated at BIPM (France) [1]. This neutron source is the Brazilian standard for neutron emission (neutron fluence). The value of neutron emission rate is obtained using the following expression:

$$Q = QMn \ \ 1/F \ \ K \ \ (s^{-1}) \tag{1}$$

where: Q = neutron source emission rate (n/s 4π);
QMn = neutron capture rate by Mn atoms in the solution;
F = ratio of captured neutrons by Mn atoms and captured by other elements (S, O, H) in the solution;
K = correction factor that include self-absorption, fast neutron absorption by O and S atoms, and neutron leakage from bath.

Figure 1. Manganese Sulfate Bath located at LNMRI/LN – Laboratório de Nêutrons

The MnSO4 concentration solution is 443.90g/l. All measurements are made in temperature controlled room to avoid drift on the gain of electronic detection system.

For each test in the manganese bath it was carried out 10 measurements of decay activity. Each measurement is counted by a period of 500 seconds with interval of 3 seconds between each one. All the measurements are corrected to saturation activity.

In each test it was also evaluated the background radiation. The values are showed in the Fig. 2. The average value for 11 measurements is (4.829 ± 0.022) counts per second (2σ).

Fig. 3 shows the results of saturation counts rate from the MnSO4 bath. The average value for 11 measurements is (523.705 ± 1.422) counts per second (2σ).

The neutron emission rate value for the neutron source in each test was obtained applying the Eq. 1. The results are presented in the Fig. 4. The 12th point showed in the graph was obtained at BIPM – France $(2.217 \pm 0.032) \times 10^6$ neutron per second (2σ). The average value obtained at LN for the eleven measurements showed in the Fig. 4 is $(2.214 \pm 0.033) \times 10^6$ neutron per second (2σ).

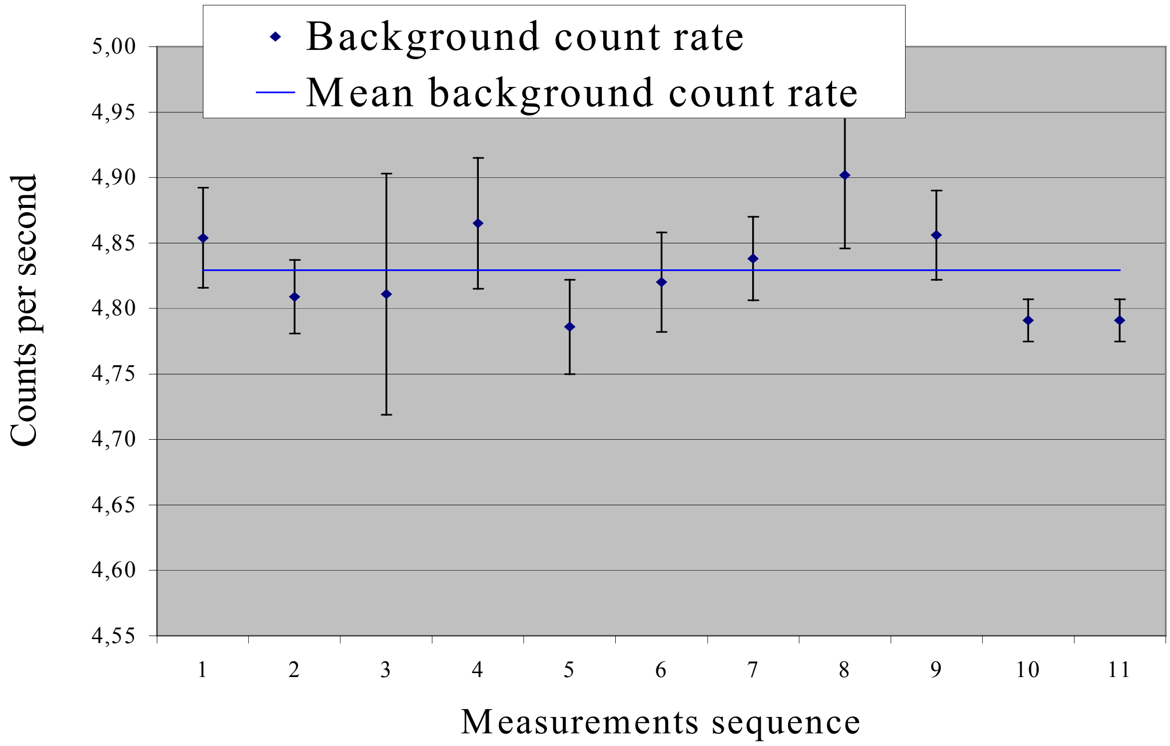

Figure 2. Background radiation values.

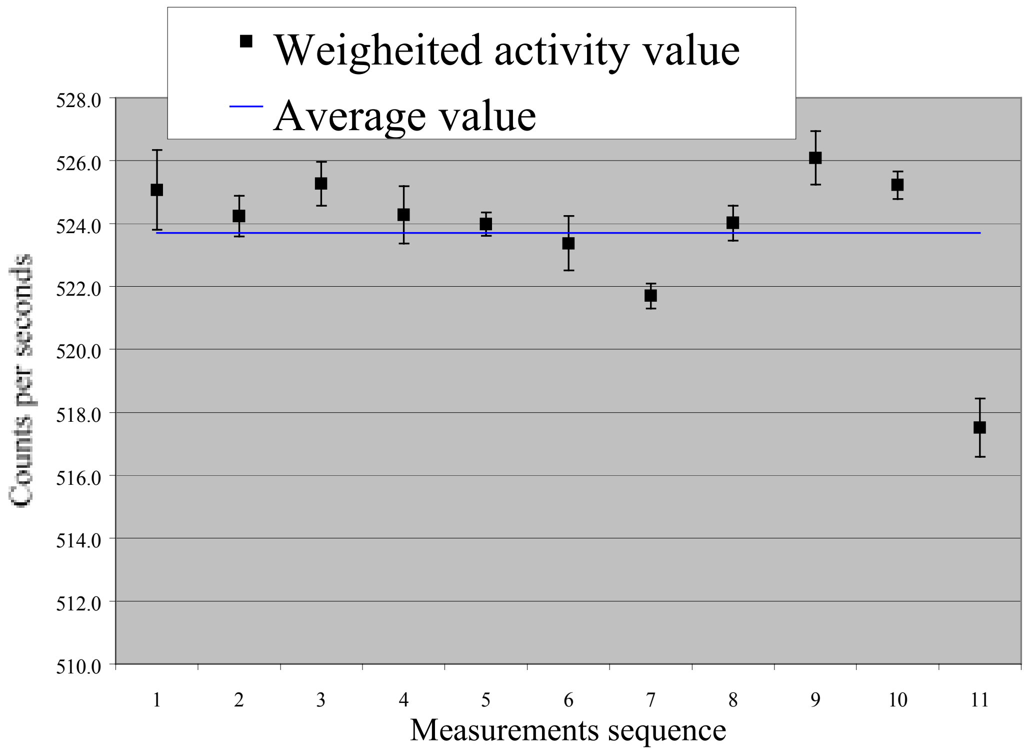

Figure 3. Manganese bath saturation count rate.

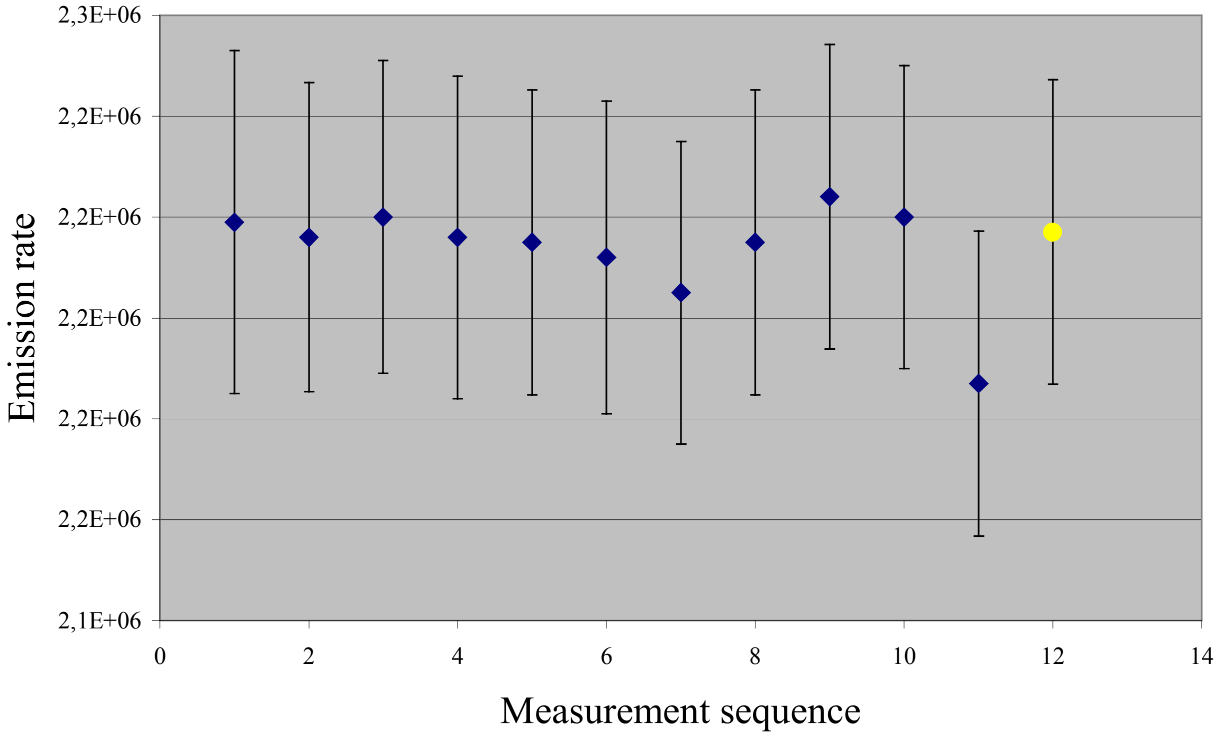

Figure 4. Values of neutron source emission rate obtained during the tests at LNMRI/LN – Laboratório de Nêutrons.

The mean value of ^{56}Mn decay constant was calculated using the measurements obtained in each test was 7.5475 x 10^{-5} s^{-1}. One can observe that these results come from adjusting the decay measures by means of one exponential expression. The ^{56}Mn decay constant value 7.4672 x 10^{-5} s^{-1} [2] was used for calculation of the neutron source emission rate

IV. CONCLUSION

The results showed that the LNMRI/LN – Laboratório de Nêutrons is able to maintain the reproducibility of the measurements and the traceability of neutron source emission rate to BIPM reference value. Unfortunately, the last measurement point shows a going down trend. This result is under investigation to try to discover which parameters influenced on the final mean. Other tests have been done using different kind of neutron sources spectra to evaluate how this parameter influence over the final value of neutron emission rate. The neutron leakage from manganese bath will be studied using experimental measurements and Monte Carlo simulation in order to be compared.

V. REFERENCES

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