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VERIFICATION OF ^{235}U BY USING MCNP CODE WITH COMPARISON MGAU ANALYSIS SOFTWARE FOR DEPLETED AND ENTRUSTMENT URANIUM

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ABSTRACT

The current research was based on non-devastating measurements of gamma radiation. There are two samples under investigation which are depleted and enriched uranium. the obtained results that depended on MCNP-5 were in great understandings with the pronounced values inside the evaluated relative precision. the researchers can declare that, the Monte Carlo method fits the measurement conditions of the inspector. The relative accuracy obtained from MGAU were (0.447 and 0.187%) and (3.3 and 15.9%) for enriched uranium and depleted uranium, respectively

1. Introduction

A basic degree of a State Framework of Bookkeeping and Control may be a framework of estimations. The most work of that framework is to confirm of nuclear matters (NMs) within the State. Verification exercises are accomplished by means of two fundamental steps. To begin with, the office administrator is obliged to supply the auditor with all data important to NMs stock and stock changes. (IAEA, 1980). Second, the measured amounts of NMs are compared with those pronounced by office administrators. The data of operators' affirmations depends on a few criteria, which are related to the exactness and exactness of the estimation comes about for both auditors and administrators (IAEA, 2001; Eurachem, 1995).

Control reactors may be fabricated from LEU oxide powders within the frame of fuel pellets, poles, plates, etc., and collected as fuel gatherings, components or bundles. Guidelines of NMs of well-known enhancements and of comparable characteristics to the tested fuel test are as a rule required for performing improvement calibration of the measuring framework. Such NM Benchmarks may not be accessible or suitable for the reason totally different circumstances. Later ponders are coordinated towards overcoming this issue. (Hagenauer, 1986; Reilly et al., 1991; Badawy et al., 1996; Badawy et al., 1999; Gunnink et al., 1997; Saleh et al., 2018; Mansour et al., 2017).

Relative efficiency curves determination (Ludington et al, 2000) and simulation of energy spectra (Wang et al, 1994) The MCNP-5 code was utilized in recreating the neutron transport for deciding the measurements rate. In any case, the Monte Carlo N-Particle (MCNP) code is used in three dimension and is able of following up to many particles. (Monte Carlo Group, 2016; Ruegg C., 2014; Thomsen K., 2014; Reiss et al, 2013; Plyku D et al, 2015; Sangkaew et al, 2017).

2. Standard Nuclear Material Verification

^{235}U mass substance in NMs considered in this work, and were confirmed on the premise of detached supreme nondestructive measure strategies by utilizing hyper immaculate germanium and the Monte Carlo Program (MCNP-5). A measured test must be found at remove D before the locator such that the pivot of symmetry of the detector is opposite to the surface of the fabric test and passing through its center. Appropriately the net tally rate for the measured atomic fabric test can be gotten applying the following: (Ahmed et al, 2019)

$$C_R = M_{235} \, . \, S_{185} \, . \, A_t \, . \, \Omega_f \, . \, \varepsilon_i \, . \, F_e \, . \, F_c \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where,

M_{235} is the mass of ^{235}U in grams.

S_{185} is activity of the 185.7 keV

A_t is the whole weakening rectification figure for fabric arrangement set up.

Ω_f is the fragmentary strong point of the fabric subtended by the locator.

ε_i is the natural full vitality crest effectiveness of the locator at 185.7 keV gamma vitality.

F_e could be a rectification calculate for electronic misfortunes (due to pileup and dead time) and Fc may be a redress figure for encompassing foundation and coincidence summing. The Equation (1) can be simplified to become:

$$C_R = M_{235} \, . \, S_{185} \, . \, A_t \, . \, \Omega_f \, . \, \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The evaluated U-235 mass based on MGAU can be calculated applying the taking after condition,

$$\mathbf{M_{U\text{-}235}} = E_{U235} \,.\, M_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where, E_{U235} is the enhancement Uranium. (Ahmed et al, 2019)

3. Experimental work

A. Measurements:

The SNM enhancement and exhausted were measured utilizing Germanium detector with MGAU examination computer program. The measurements were not limited with the field requirements. Consequently, the measurements are not representing a state of practice ones, which met the inspection working conditions.

B. Measurements Setup of NM Sample

The primary is composed of drained uranium, whereas the moment is the entrustment uranium. The compositions of samples are U_3O_8. All the tests were measured with symmetric arrangements with regard to the finder. Each NMs was found so that the hub of symmetry of the finder passes through the central point of the measured one. For all measured NMs, the remove between the test and finder for each test were chosen and changed taking into thought that blunders due to electronic misfortunes are continuously kept as conceivable.

C. Standard Nuclear Material

The determinations of the Standard (SNM) utilized within the display think about are given in Table (1). The experimental setup configuration for this measurement is shown in Figure (1).

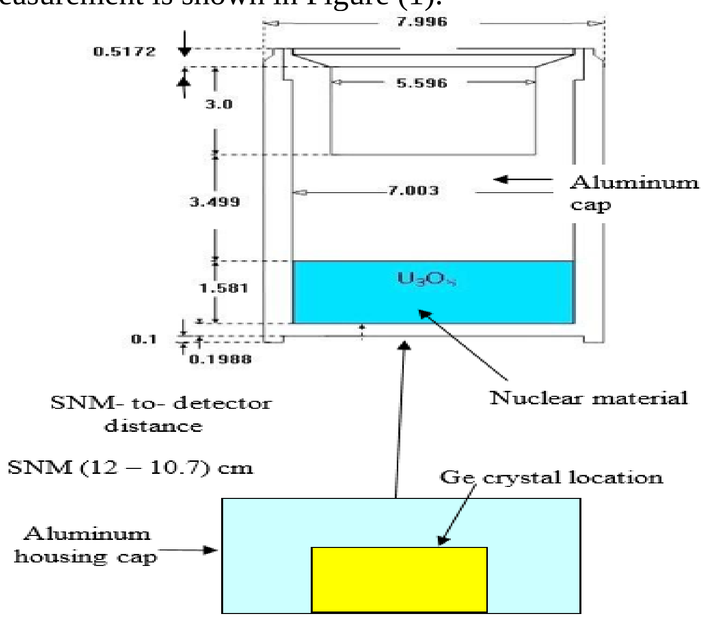

Fig. 1. *A chart for illustrating the shape and dimensions of a standard nuclear material and the HPGe detector*

4. Results and interpretation

The current work is committed to investigate and describe an absolute passive non-destructive assay method to verify ^{235}U isotopic mass contents in uranium

samples. The method is based on counting the 185.7 keV gamma-rays of ^{235}U, using high-resolution germanium gamma-rays detector and calculating some factors that affect the measurements using MCNP-5 code.
According to equations (4) and (5), ^{235}U mass content was calculated based on MCNP calculations and MGAU software, respectively.

Table (1). *Details of the standard materials (SNM) [31].*

Sample ID	Container				NMs height (cm)	$^{235}U/U_T$ atom %
	height (cm)	thickness(cm)	In diameter (cm)	Out diameter. (cm)		
SNM	8.897	0.1994	7.003	7.996	1.581	0.32 2.94

Table (2). *The estimated ^{235}U based on MGAU measurements value.*

Sample Location	D (cm)	U M(g)± SD			E_G x10^{-2} ±SD	Life time (min)	R_{DG} %
		M_T	M_D	M_G			
L	13.4	169.66± 0.00001	5.003613 ±0.0001	4.98 ± 0.03303815	2.94 ± 0.033	501	0.45

1. **The enriched uranium (2.94 %).**

a. **The obtained result from MGAU software**

Table (2) shows the estimated mass of ^{235}U in sample comparison with the pronounced values. This Table lists the sample location, the sample to detector distance (DIST), the total mass uranium (M_T), the declared value of ^{235}U (M_D) with the assessed rate relative standard deviation (SD%), the measured improvement based on MGAU computer program (EG) with the related SD%, the evaluated U mass (MG) (based on EG) with the evaluated SD% and the rate relative exactness (RDG%). [$R_{DG}\%=((M_D - M_G)/M_D)*100$].

b. **The obtained result from MCNP calculation.**

The estimated ^{235}U parameters are given in Table (3). In expansion to the test area, DIST, announced mass and assessed U-235 mass (MM), the measured tally rates (CR) and outright full vitality efficiency (εab) are given. the overall error was estimated using uncertainties equation.
The estimated ^{235}U masses are 4.98 and 4.936 for MGAU and MCNP-5 methods. The correctness for both strategies are 0.4476 and 1.341%.
Figure (2) summarise the obtained results for M_G and M_M with associated uncertainties (error bars) compared with M_D. The Figure illustrates the assenting of the evaluated masses with the pronounced mass inside the related instabilities. Both the two estimation methods for ^{235}U mass are accurate. The precision of MGAU results could be improved through extending the time of measurement, but this is impossible in the field of inspection. While more

accurate results can also be obtained by reducing systematic errors due to sample position in case of MCNP-5 method with the short life time for measurement sample.

2. The depleted uranium

The estimated mass of ^{235}U in sample based on MGAU and on MC are given in Table (5).

The estimated ^{235}U masses are 0.543 and 0.539 for MGAU and MCNP-5 methods. The exactness's for both strategies are 0.187 and 0.768%, respectively.

Figure (3) presents the obtained results for M_G and M_M with associated uncertainties in relation with M_D.

It is noticeable that, the (DIST) was (13.4 and 12 cm) for enriched uranium and depleted uranium in case of MGAU, respectively. On other hand, it was (12 and 10.7 cm) in case of MCNP, respectively. There is a difference about 1.4 and 1.3 for enriched uranium and depleted uranium, respectively. This is due to a systematic error at the tip of the measuring instrument (1.4 cm). In addition, there is a random error in the case of depleted uranium (0.1 cm) because of the exact location of the sample is not determined with high accuracy.

Finally, the following observations can be recorded:-

1- All the gotten comes about based on MCNP-5 are in assenting with the pronounced values inside the evaluated relative precision (1.341 and 0.768%) and relative accuracy (1.34 and 2.15%) for improved uranium and exhausted uranium, separately. In any case, these comes about can be acknowledged in comparison with later comparable cases of ITVs (UNSCEAR, 2000).

2- The relative precision gotten from MGAU were (0.447 and 0.187%) and relative exactness (3.3 and 15.9%) for enhanced uranium and depleted uranium, separately. But the relative accuracy is generally expansive in case of drained uranium. It was assumed to be due to the brief life time of estimations.

3- Although MGAU might give coordinate comes about for U-isotopes in a few cases, it needs a moderately long time of estimation. In addition, its examination depends on a range calculated at the X-ray locale which can be not viable at whatever point the measured fabric is contained indeed in an overwhelming protecting fabric (Abousahla et al, 1996). This is contrary to the conditions of the inspector at the facility.

4- The (MCNP-5) method depends on the measured gamma-rays at 185.7 keV energy, but doesn't depend on the measurement time.

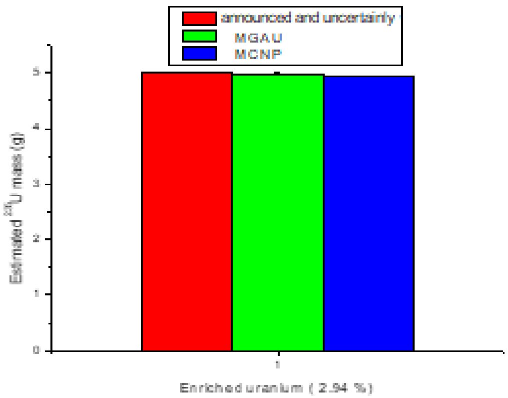

Fig.3*.The assessed U based on MCNP and MGUA strategies in connection with the announced esteem for depleted uranium test.*

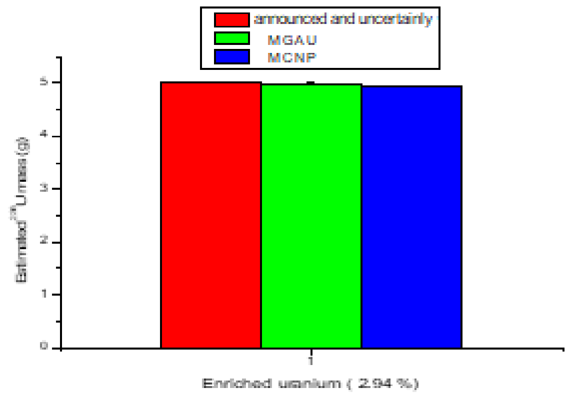

Fig. 2. *The assessed U based on MCNP and MGUA strategies for uranium (2.94 %) sample.*

5. Conclusion

It might be at long last concluded that with a few exact information with respect to the measured test, finder characteristics and experimental setup arrangement, the explored strategy may well be utilized to confirm NMs for enriched uranium and depleted uranium with acceptable exactness. The researchers think that the Monte Carlo method fits the measurement conditions of the inspector and also the conditions for normal measurements are therefore better than MGAU method.
The created method can be successfully utilized to control NMs in fuel and perform physical stock taking exercises (PIT).
This procedure seems too give the fundamental premise for (PIT) exercises in a fuel manufacture office for atomic reactors. nuclear reactors.

References

Abousahla S., A. Michielsa, M. Bickela, R. Gunninkb, J. Verplanckec, 1996. Applicability and limits of the MGAU code for the determination of the enrichment of uranium samples. Nuclear Instruments and Methods in Physics Research A 368, 443-448.

Ahmed. G. Mostafa, Sayed. Makhlouf, Elham. El-hakim, Morsy. S. El-Tahawy, Abdel Fatah. A. Hamed, Atef El-Taher, 2019. The Verification from Uranium Oxide Powders in Different Forms by Non-destructive Assay Using MCNP5 with Comparison MGAU. Arabian Journal for Science and Engineering.

Badawy I. et al., 1996. Measurement of uranium fuel elements without use of nuclear material standards. Proceedings of the 19th ESARDA

Symposium on Safeguards and Nuclear Material Management, Montpellier, France, pp. 525-530.

Badawy I., W.A. El-Gammal, 1999. Measurement of low enriched uranium fuel pellets, Proceedings of the Sixth National Radio Science Conference H12, Cairo, Egypt, pp. 1-8.

Eurachem Guide,1995. Quantifying uncertainty in analytical measurement. Laboratory of the Government Chemist, London (1995). ISBN 0-948926-08-2.

Gunnink R. et al., 1997. New Ge and NaI analysis method for measuring ^{235}U enrichment, Proceedings of the 19th ESARDA Symposium on Safeguards and Nuclear Material Management, Montpellier, France, pp. 431-435.

Hagenauer, R.C, 1986. Nondestructive assay of uranium in infinitely-thick material. Nucl. Instr. and Meth. A 242 (3) PP 574- 576.

IAEA, 1998. The Evolution of IAEA Safeguards. International Nuclear Verification Series No. 2, Vienna, Austria (1998).

IAEA, 1980. Guidelines for states' systems of accounting for and control of nuclear materials, IAEA/SG/INF/2, IAEA, Vienna, Austria, (1980).

IAEA, 2001. International Target values 2000 for measurement uncertainties in safeguarding nuclear materials, Department of safeguards, STR-327, (2001).

Ludington M.A., R.G. Helmer, 2000. High accuracy measurements and Monte Carlo calculations of the relative efficiency curve of an HPGe detector from 433 to 2754 keV. Nucl. Instr. and Meth. A 446 (3) 506.

Monte Carlo Group: Los Alamos National Laboratory [Online] Available: https://mcnp.lanl.gov [Accessed24 11 2016].

Mansour, H. et al, 2017. Distribution of Natural Radionuclides for Sedimentary Rock Samples from South western Sinai and Their Environmental Impacts, Egypt. Int J Recent Sci Res. 8(11), 21715-21721. http://dx.doi.org/10.24327/ijrsr.2017.0811.1125

Plyku D, Loeb D M, Prideaux A R, Baechler S, Wahl R L, Sgouros G and Hobbs R F, 2015. Strengths and Weaknesses of a Planar Whole-Body Method of ^{153}Sm Dosimetry for Patients with Metastatic Osteosarcoma and Comparison with Three-Dimensional Dosimetry. Cancer Biotherapy and Radiopharmaceuticals 30 369.

Reilly D. et al., 1991. Passive nondestructive assay of nuclear material, US Nuclear Regulatory Commission, NUREG/CR-55, LA-UR-90-732 Washington, DC, USA, (1991).

Reiss T, Filges U, Gallmeier F, Talanov V and Wohlmuther M, 2013. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 728 117 {125 ISSN 0168-9002 URL. http://www.sciencedirect.com/science/article/pii/S016890021300947 9.

Ruegg C, 2014. Upgrade plans for SINQ {moderators, guides, instruments, and new science 21st Meeting of the International Collaboration on Advanced Neutron Sources} (ICANS-XXI) (Mito, Japan).

Saleh Alashrah, Atef El-Taher, Howaida Mansour, 2018. Assessment of radiological parameters and metal contents in soil and stone samples from Harrat Al Madinah, Saudi Arabia. MethodsX, (5), PP 485-494.

Sangkaew S, T Angwongtrakool and B Srimok, 2017. Fuel burnup analysis for Thai research reactor by using MCNPX computer code Published under licence by IOP Publishing Ltd Journal of Physics. Conference Series, Volume 860, conference 1 Journal article OPEN ACCESS 2017 1742-6596 860 012033 doi:10.1088/1742- 6596/860/1/012033.

Thomsen K, 2014. Physics Procedia 60 278 {293 ISSN 1875-3892 3rd International Meeting of the Union for Compact Accelerator-driven Neutron Sources}, UCANS-III, 31 July - 3 August, 2012, Bilbao, Spain & the 4th International Meeting of the Union for Compact Accelerator-driven Neutron Sources, UCANS-IV, 23-27 September 2013, Sapporo, Hokkaido, Japan URL. http://www.sciencedirect.com/science/article/pii/S1875389214005859.

UNSCEAR, 2000. International Target Values for Measurement Uncertainties in Safeguarding Nuclear Materials. Report to General Assembly, with Scientific Annexes. United Nations, New York (2000).

Wang T.F., J.B. Carlson, Z.M. Koenig, W.D. Ruhter, T.S.H. Lee, J. Winn, 1994. Nucl. Instr. and Meth. A 353 (1–3) 678.