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STATISTICAL EVALUATION OF RELEASES OF C-14 FROM THE VIENNA TRIGA REACTOR

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Recently the releases of C-14 from different sources gained increasing interest. This is because this radionuclide contributes with its long half life significantly to the collective dose commitment.

Measurement of the release rate of C-14 as CO_2 were carried out from 1979 to 1984 at the Vienna Triga reactor. These results show large differences. Due to the large number of available data, a statistical evaluation of data seem promising. This evaluation has shown that the releases fit quite well a normal distribution, indicating that the release of C-14 as CO_2 from a TRIGA reactor is a random process.

Introduction

C-14 gained specific interest recently and different sources as power reactors, research reactors,burial sites etc. are under investigation.

Production of C-14 in a reactor

C-14 in reactors is produced by different reactions, which are shown in Table I

Table I
Reactions producing ^{14}C in reactors

Reaction	Cross section (barns)	Natural isotopic abundance of target element (%)
N-14(n,p)C-14	1.8	99.634
O-17(n,α)C-14	0.235	0.039
C-13(n,γ)C-14	0.9×10^{-4}	1.11
N-15(n,α)C-14	2.5×10^{-7}	0.366
O-16(n,He-3)C-14	5×10^{-8}	99.759
U-235(n,f)C-14	$1.7/10^{6}$ fissions	
Pu-239(n,f)C-14	$1.8/10^{6}$ fissions	

It can therefore be expected that C-14 is produced in the fuel, the cooling medium and other reactor components. Although estimates on the production rate are available, the actual release rate can be assessed only by measurements due to the complexicity of release modes.

Reactor operation conditions

The reactor was operated in normal mode in the time interval the measurementswere carried out. However, one important component of the reactor, the rotary specimen rack, an irradiation facility,was dismantled for mechanical failure reasons. After this, a substantial lower release rate was found.

Measuring techniques

Sampling and sample preparation

Grab sampling was found as to be not sufficient, and therefore a continuous sampling system was used for sample preparation and an air flow of about 1 l/min passed the separation unit. The separation procedure based on the standard reaction.

$$2\ NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$

After sampling, the following reaction was carried out

$$Na_2CO_3 + CaCl \rightarrow CaCO_3 + 2\ NaCl$$

$CaCO_3$ was used because of the lower LLD (Lower Limit of Detection) which can be obtained than using $BaCO_3$ (see [1]).

Measurement

The $CaCO_3$ precipitated was eventually counted in a liquid scintillation counter. A scintillation cocktail of 12 ml Instagel + 8.3 g $CaCO_3$ + 6 ml H_2O was used. This composition, mixed at about 40° C and cooled down rapidly, constitutes a rather stable gel. Details on this procedure can be found in [1].

Results

Regarding the results, some of these covering 1979 and 1980 are already published [2]. The measurements were continued until 1984 and the results are shown in Figure 1.

It can be seen that the measurements from 1981 to 1984 confirmed the data already obtained, further it can be seen that no clear correlation can be found between thermal energy and release per unit time. Therefore, a statistical data evaluation seems promising.

Statistical evaluation of data

From Figure 2 it can be seen that the distribution of the activity concentration is very well fitted by a normal distribution for both operating conditions (with and without rotary specimen rack). No further correlation with reactor operating conditions was found. This indicates that the release of ^{14}C from a swimming pool reactor is a random process.

Conclusions

The release rate associated mainly with activation of water has a mean of 70 ± 50 $kBq/MW_{th}.h$, the release rate mainly by activation of air (with rotary specimen rack) 300 ± 150 $kBq/MW_{th}.h$. In both cases, no correlation with operational parameters was found, but only combined influences. This leads to the statistical distribution of data.

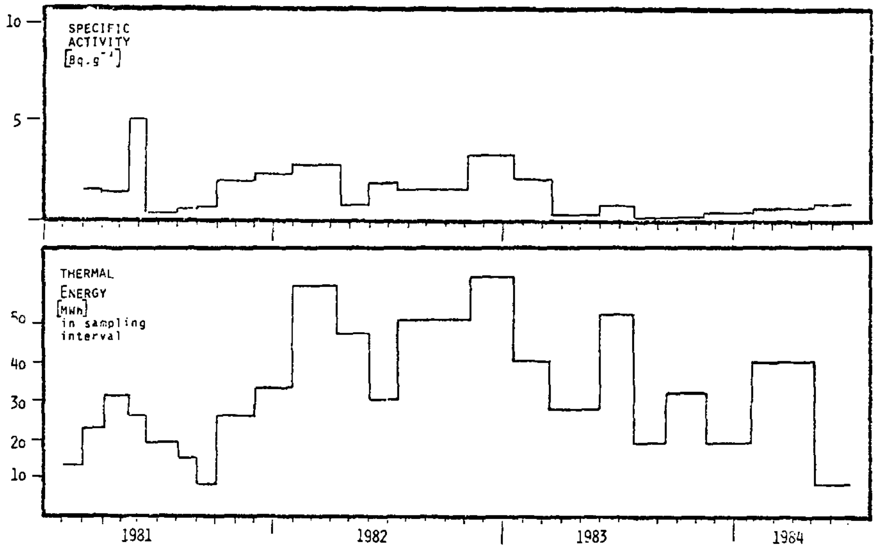

Fig.1. Results of release monitoring

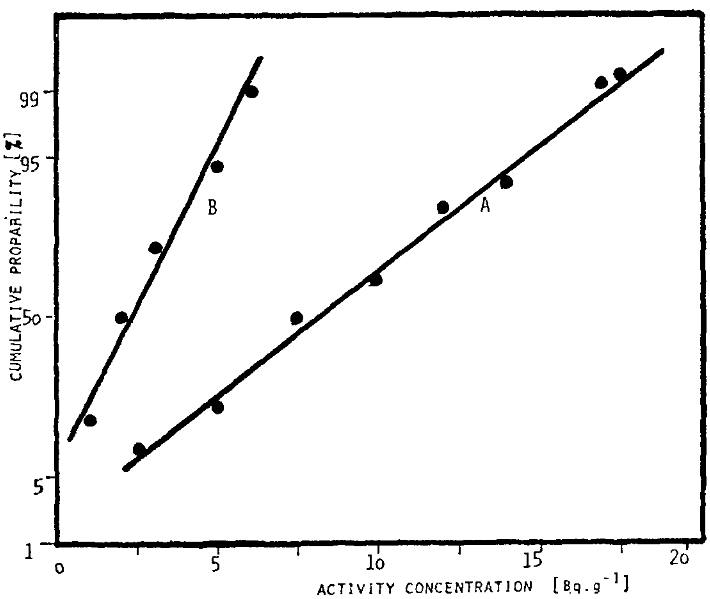

Fig.2. Statistical evaluation of data
A. with rotary specimen rack,B. without rotary specimen rack

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References

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