**THERMAL RAMP TRITIUM RELEASE IN COBRA-1A2 C03 BERYLLIUM PEBBLES -**
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## OBJECTIVE

The purpose of this work was to provide quantitative tritium release response from prototypic irradiated beryllium pebbles. Such pebbles are under consideration as the neutron multiplier medium in the European Fusion Technology Program Helium Cooled Pebble Bed (HCPB) Blanket.

## SUMMARY

Tritium release kinetics, using the method of thermal ramp heating at three linear ramp rates, were measured on the COBRA-1A2 C03 1-mm beryllium pebbles. This report includes a brief discussion of the test, and the test data in graph format.

## PROGRESS AND STATUS

### Introduction

Beryllium pebbles are being considered for the neutron multiplier medium in the European Fusion Technology Program Helium Cooled Pebble Bed (HCPB) Blanket. That design is also being considered for testing ITER. The pebbles to be used are an inexpensive form of beryllium produced in an intermediate step of the production of higher purity beryllium. The opportunity to obtain tritium release response from prototypic fast neutron irradiated pebbles became possible after pebbles were irradiated in the US/DOE COBRA-1A2 experiment in EBR-II. Experimental details are provided in a companion paper [1]. The tritium release measurements were funded by Forschungszentrum Karlsruhe.

### Experimental Procedure

The thermal ramp heating method for tritium release kinetics was performed on the C03 1-mm Be pebbles using 15 pebbles for each of three tests. The three tests were conducted over a decade range of ramp rates at 0.5, 2.0, and 5.0°C/min. The temperature range for all tests was 300-900°C. Table 1 shows the ramp rates and sample weights. A ramp maximum temperature of 850°C was initially planned for the tests. However, a scoping test was performed, and the results indicated a $T_{max}$ for this Be of >850°C, therefore, the ramp maximum was increased to 900°C.

Briefly, the sample was heated in a sweep gas of He+0.1%$H_2$ at 100 SCCM, the released tritium measured in real-time by an ion chamber, then oxidized on copper oxide and collected in a pair of water bubblers, and finally measured by liquid scintillation counting. The ramp rates were preselected as specified. After loading the weighed sample pebbles, the system was purged before heating was begun. After the temperature ramp was completed, the sample temperature was held at the maximum of 900°C for a period of time ranging from 4 to 18 hours, as seen in the plots.

*Pacific Northwest National Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

Discussion of Results

The plots of the thermal ramp test data for this C03 Be material are shown in Figures 1 through 5. Figure 1 shows the tritium release rate on a log axis versus time in hours, and a temperature ramp of 0.5°C/min. Similarly, Figures 2 and 3 show the analogous curves at ramp rates of 2.0 and 5.0°C/min. Figure 4 shows all three test curves of release rate versus time, with the release rate on linear axis, and with the corresponding temperature profiles, for comparison purposes. The difference in the release curve shapes and peak widths can be

seen clearly in this plot. Figure 5 shows a different view, of all three test curves of release rate versus temperature in °C, again with release rate on linear axis, for comparison purposes.

Table 2 shows release kinetics parameters as determined from this data. The parameter P, in Bq/g, is the "production" rate as measured by the assay test reported earlier, not as calculated from the fluence prediction; R, in Bq/g, is the measured total release from the sample as determined from the bubbler liquid scintillation results; R/P, in percent, is the fractional release at end of test; the temperature, $T_{max}$, corresponds to the temperature of peak maximum release rate; and DF is the factor by which the release rate decreases, at 900°C in 3 hours.

Table 1. Be pebble sample and test parameters

| Sample material | Thermal ramp rate (°C/min) | # of pebbles | Sample weight (g) |
|---|---|---|---|
| C03 Be pebbles (1-mm) | 0.5 | 15 | 0.0188 |
| | 2.0 | 15 | 0.0178 |
| | 5.0 | 15 | 0.0179 |

Table 2. Tritium release parameters

| Material | Ramp rate | P [Bq/g] | R [Bq/g] | R/P [%] | $T_{max}$ [°C] | DF |
|---|---|---|---|---|---|---|
| C03 (1-mm) Be pebbles | 0.5°C/min | 1.13 E+09 | 1.04 E+09 | 92% | 882 | 3.1 |
| | 2.0°C/min | 1.13 E+09 | 1.14 E+09 | 100% | 887 | 8.5 |
| | 5.0°C/min | 1.13 E+09 | 1.07 E+09 | 95% | 900 | 11.4 |

As can be seen in the table, the fractional release, R/P, is high in these 1-mm pebbles, >92% in all cases. The $T_{max}$ for the three cases shows a slight increase with increasing ramp rate, from 882°C to 900°C, as expected. The DF is consistently low for this material, ranging from 3.1 to 11.4, even at the high hold temperature of 900°C, indicating only gradual continuing release at the hold temperature. These DF numbers are low compared with other studied beryllium specimens.

As has been done previously, the IC cumulative release curve in MBq/g, calculated from the release rate curve in Bq/s, was normalized to the collection bubbler liquid scintillation results in MBq/g. This was done by adjusting the IC baseline and/or IC calibration factor for each

bubbler data point. This method assumes the collection bubbler liquid scintillation results are always reliable and accurate, therefore, the IC curve must be adjusted to obtain agreement. The full data file is also attached, in Excel 4.0 format.

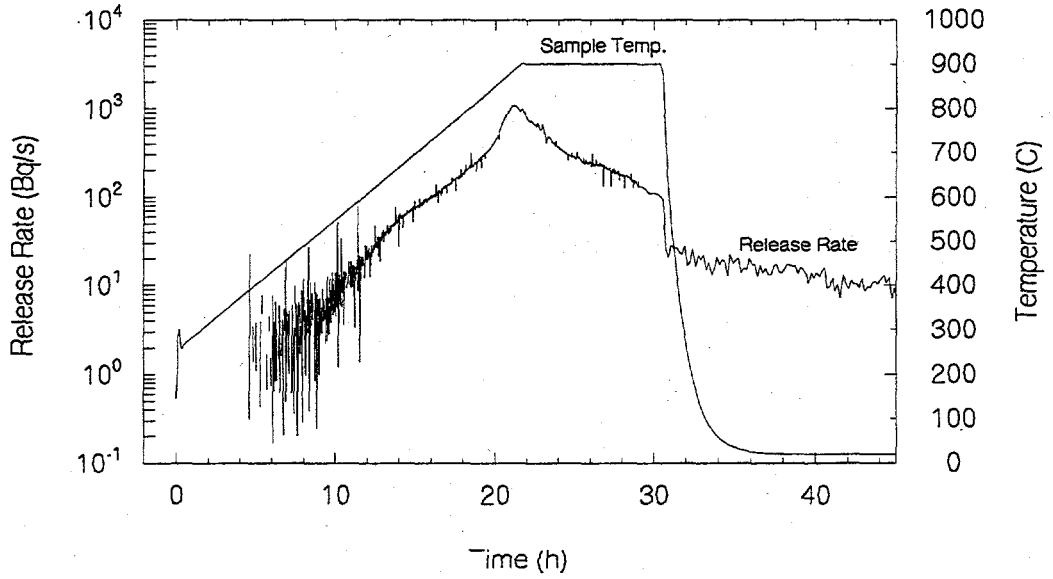


Figure 1. Tritium release kinetics for C03, 1-mm pebbles, thermal ramp test at 0.5°C/min ramp rate.

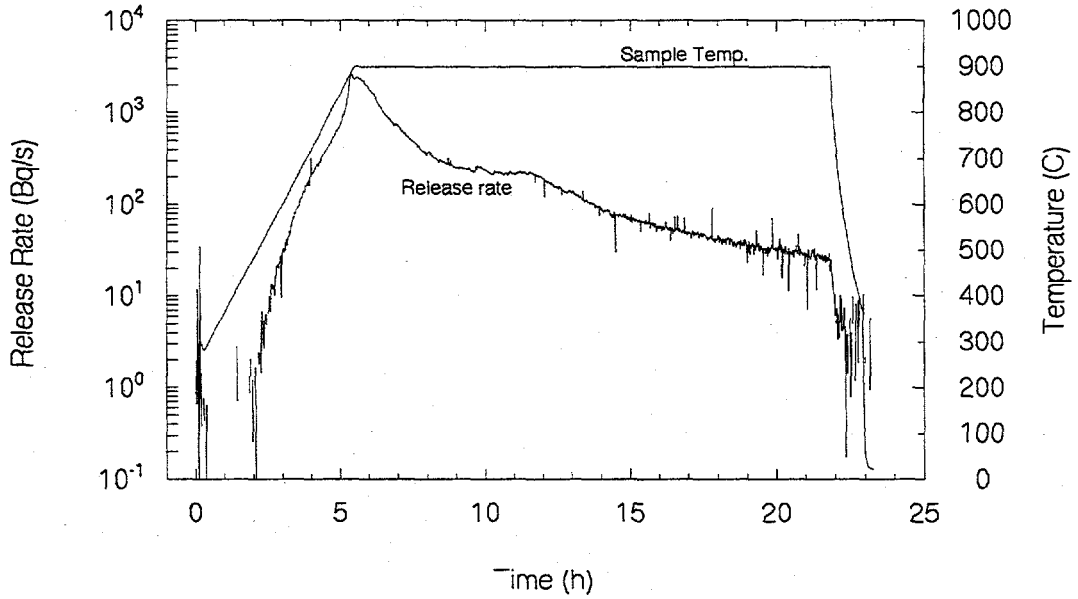


Figure 2. Tritium release kinetics for C03, 1-mm pebbles, thermal ramp test at 2.0°C/min ramp rate.

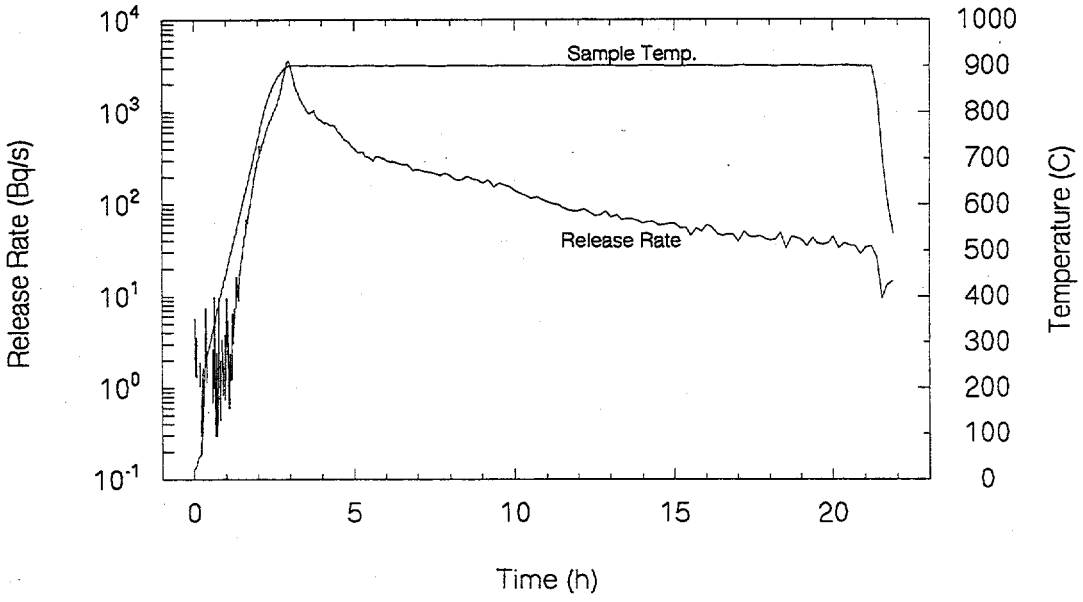


Figure 3. Tritium release kinetics for C03, 1-mm pebbles, thermal ramp test at 5.0°C/min ramp rate.

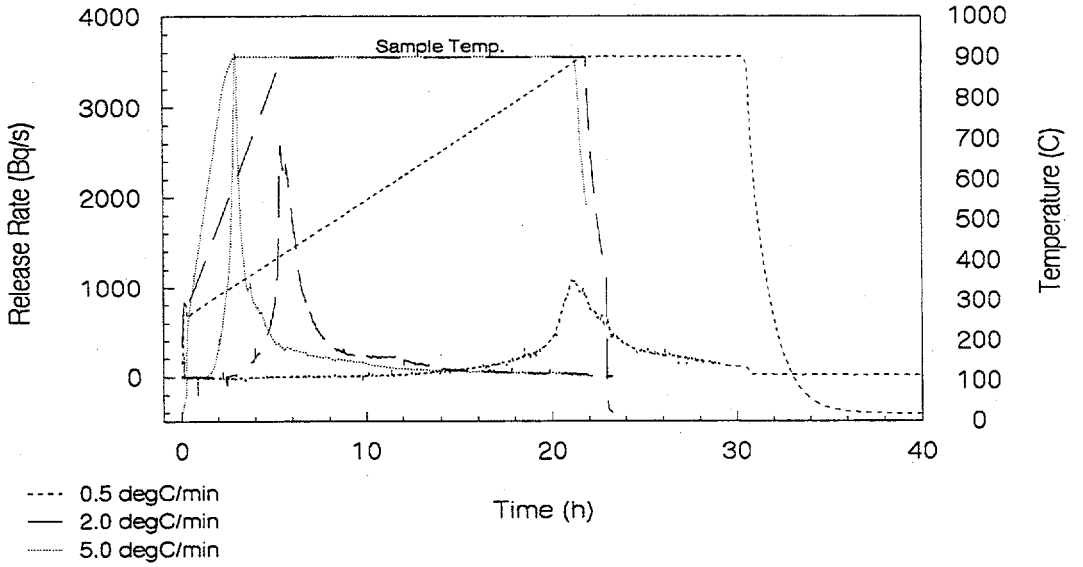


Figure 4. Tritium release kinetics for C03, 1-mm pebbles, thermal ramp tests, showing summary plot of release rate versus time, at 0.5, 2.0, and 5.0°C/min ramp rates, on linear y-axis.

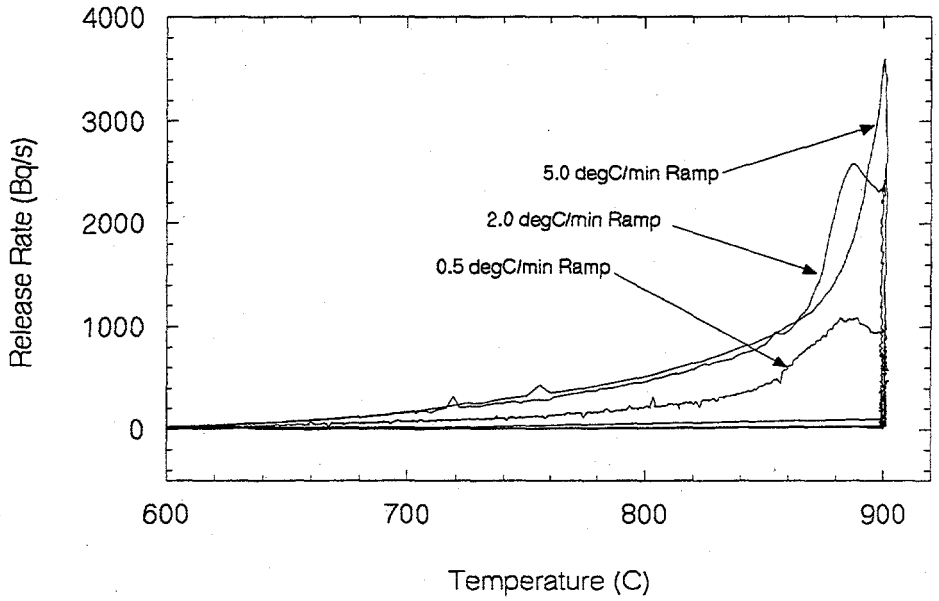


Figure 5. Tritium release kinetics for C03, 1-mm pebbles, thermal ramp tests, showing summary plot of release rate versus temperature, at 0.5, 2.0, and 5.0°C/min ramp rates, on linear y-axis.

## FUTURE WORK

This work is completed.

## ACKNOWLEDGEMENTS

Specimens for irradiation were provided by H. Kawamura of JAERI as part of the US/DOE MONBUSHO Fusion Materials Program. The tritium release measurements were funded by Forschungszentrum Karlsruhe under project 26919 with Battelle Pacific Northwest Laboratory entitled Post-Irradiation Examination of Beryllium. This project was under the direction of Prof. M. Dalle Donne.

## REFERENCES

1. D. S. Gelles, "US/DOE OFES Neutron Irradiation Experiments containing Berylium," in this DOE/ER-0313/23 report.