

D. Campling, P. Macheta, B. Patel, and P. Schofield

Tritium-in-Air ‘Bubbler’ Samplers and Internal Radiation Doses at JET

Tritium-in-Air 'Bubbler' Samplers and Internal Radiation Doses at JET

D. Campling, P. Macheta, B. Patel, and P. Schofield

Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, OX14 3DB, UK

Pre-Print of paper to be submitted for publication in proceedings of the
6th International Conference on Tritium Science and Technology, Tsukuba, Japan, 11 - 16 Noember, 2001

“This document is intended for publication in the open literature. It is made available on the understanding that it may not be further circulated and extracts or references may not be published prior to publication of the original when applicable, or without the consent of the Publications Officer, EFDA, Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK.”

“Enquiries about Copyright and reproduction should be addressed to the Publications Officer, EFDA, Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK.”

INTRODUCTION

Tritium-in-air bubbler samplers have been used extensively at the UKAEA Culham-JET facilities to monitor airborne tritium contamination in a wide variety of locations, from inside the torus to analysis laboratories. The samplers exploit the isotopic exchange between tritiated water vapour in the environmental air and analar water in a twin stage bubbler system to derive the concentration of tritium in the workplace air. These samplers give consistent results down to a few 10's of Bq's/m³ of air and they can be left to run unattended for long periods of time.

Theoretically there should be a correlation between an individual's exposure to tritium-in-air and the resulting tritium-in-urine measurements that are used to derive the internal doses. This paper sets out to examine, using data routinely collected by sampler operation and bioassay measurements, whether this correlation exists and to discuss the findings.

TRITIUM-IN-AIR SAMPLING

Typically a total of 2514 samplers are used annually, of these 525 (2-3 at a time) were deployed in the Torus Hall (Fig's 1 & 2).

The samplers ran for 12-hourly periods. Experimental studies using several bottles in series have shown the two-bottle system to be 95% efficient. Typically 100's - 1000's Bq/ m³ are seen depending upon the exact position of the sampler, the status of the machine (hot or cold), the ventilation conditions and any nearby work activities. These levels are equivalent to ~ 0.003-0.03 mSv/hr.

TRITIUM IN URINE SAMPLING

All workers entering the torus hall have their entry times logged automatically and access is restricted to classified radiation workers. Those involved with 'active operations' or other work in the torus hall involving an entry in excess of 30 minutes duration provided a tritium-in-urine bioassay sample to confirm the internal tritium dose. The torus hall tritium levels do not usually lead to a significant internal dose although the measurement method (liquid scintillation counting) is very sensitive. 100Bq/ l of tritium-in-urine is the threshold above background for a positive result and is equivalent to just 0.07mSv of internal dose. Only those spending several hours/day in the torus hall are likely to exceed this level but are often personnel not directly involved with active work i.e. cleaners and supervisors.

The bioassay samples are processed by the projects Approved Dosimetry Service using approved techniques. The resulting tritium-in-urine concentration is converted into an internal radiation dose using standard parameters (i.e. an average body water volume of 42 l, a biological half-life of water in the body of 10±5 days and a dose per unit intake of 1.75x10⁻¹¹Sv/Bq.)

PERIOD OF STUDY AND METHODOLOGY

The 3-4 day maintenance periods in April, September and October 2000 were used to provide the data for this study because, a significant number of torus hall entries were made and the tritium in air levels were between 1 and 2 kBq/m³. This is raised above the usual levels when access is allowed when typically a few 10's or 100's of Bq/m³ are seen. This is because the machine was kept at its operating

temperature (300°C). All individual torus hall entries were timed and those individuals spending more than 30 minutes in the area were asked to provide a tritium in urine sample. Each worker was provided with a 200ml bottle and requested to give a sample.

Those workers whose tritium-in-urine result was above the analysis-reporting threshold were entered into this study. The tritium-in-urine concentration was used to calculate the internal dose. The total torus hall entry times over each maintenance period were summed and together with the average tritium-in-air concentration a 'predicted' internal dose was calculated for each worker. This calculation assumes a standard breathing rate of 1.2m³/hr as well as the other parameters given above. The relationship between this and the calculated doses from the tritium-in-urine concentrations are presented below.

RESULTS

Figure 3 shows the data points and indicates a poor correlation between the predicted and the received internal dose. Seventeen individuals are represented; each contributed a predicted and received data point and cover a wide variety of times. In most instances the received dose is well below that which would be predicted. As expected there is a clear linear relationship between the exposure times and the predicted dose.

The possible explanations for this poor correlation are discussed below.

DISCUSSION

The most likely explanation for the overall poor correlation between these two parameters is that there was a significant (more than a few days) delay between the exposure period and the giving of the bioassay sample. This would lead to an underestimation of the 'received' dose because a significant proportion of the intake would have been cleared prior to the sample being voided.

In addition the three points representing the longest entries (>100 mins) are for cleaning staff who are likely to spend significant proportions of time in areas where the tritium concentration is much less than seen by the samplers and also undertaking relatively sedentary activities with breathing rates significantly <1.2m³/hr.

If these last three points are ignored an average correction factor of 1.28 would bring the predicted doses in line with those actually received.

In the one instance in which the received dose exceeded the predicted dose the individual was involved in an operation during which the tritium-in-air concentration would have been in excess of that seen by the bubbler sampler.

Other factors, which will add to the uncertainty but could act to increase or decrease the received dose, are differences between the concentration at the sampler and the individual and also differences between the assumed biological half-life of tritiated water and that for the person exposed.

CONCLUSION

The use of the tritium-in-air bubbler samplers has proved a useful tool for continuous monitoring

of the environment around the JET machine and in a wide variety of areas where work on contaminated components is undertaken. Together with surface smear results they are able to confirm that good contamination control practices are being maintained at the workplace.

Further studies will be undertaken when suitable conditions are encountered in order to see whether, with better control on the provision of a bioassay sample, the correlation between the predicted and received dose can be improved.

The UKAEA Culham-JET project uses strict operating procedures to protect the workforce. The use of bubbler type tritium-in-air samplers confirms that doses are kept as low as reasonably practical, for those directly and indirectly involved with tritium work in the torus hall

ACKNOWLEDGEMENTS

K Sandland and the health physics operational staff at UKAEA Culham-JET.

REFERENCES

ICRP. Annual limits on intakes by workers based on the 1990 recommendations. Pergamon Press. ICRP Publication 61: 1991c: 1-5.

This work has been performed under the European Fusion Development Agreement.

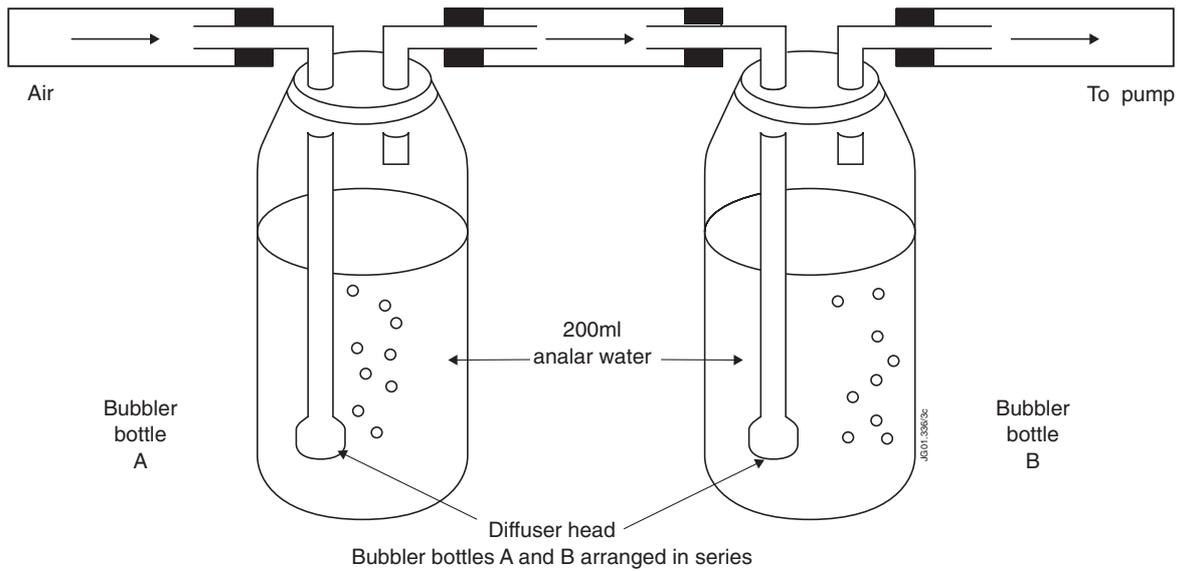


Figure 1: Diagram bubbler sampler operation.



Figure 2: Shows a typical bubbler sampler system in operation in the torus hall. Two 250ml diffuser bottles (usually held within the grey plastic cylinders) are shown connected to the black pump unit via a manometer. The assembly is housed within a red plastic box to hold any possible spillage.

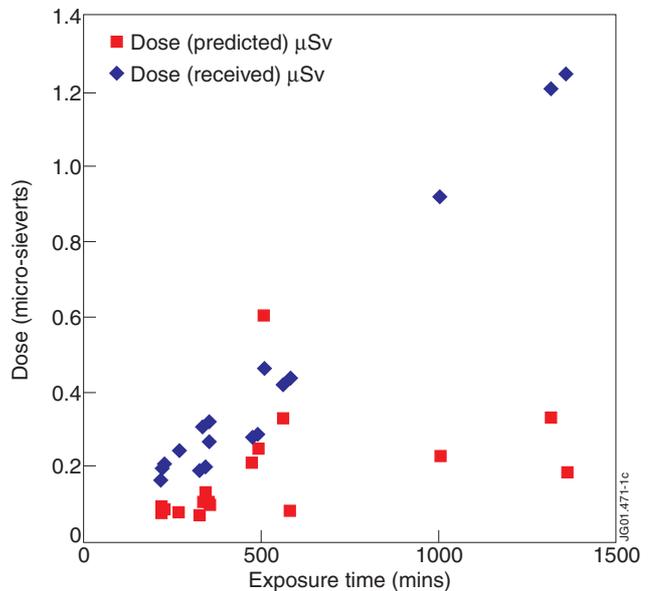


Figure 3: Predicted and received internal doses versus exposure time