Results of the 2003 NRPB Intercomparison of Passive Radon Detectors

C B Howarth and J C H Miles

ABSTRACT

As in previous years, an intercomparison of passive radon detectors was held at the National Radiological Protection Board, now the Radiation Protection Division of the Health Protection Agency, in 2003. Forty-nine laboratories submitted 65 sets of passive detectors to this intercomparison. The exercise included three exposures to radon and its decay products at different equilibrium factors. After exposure, the detectors were returned to their originating laboratories for assessment. Participants reported the estimated exposure for each detector before they were notified of the exposures given to the detectors. The results obtained by participating laboratories were classified according to the spread of results from detectors exposed together and by the difference between the mean result of each group and the actual exposure given. Forty-two percent of the laboratories achieved the highest classification for accuracy, while 23% were in the lowest category. The proportion of laboratories achieving very good results is comparable to that seen in intercomparisons carried out prior to 2000. This is despite the fact that since 2000 these exercises have included a very low radon exposure, causing larger random errors in exposure assessment. This continued improvement therefore represents a significant achievement by the participating laboratories.

Centre for Radiation, Chemical and Environmental Hazards
Radiation Protection Division
Chilton, Didcot, Oxfordshire OX11 0RQ

Approval: May 2007
Publication: June 2007
£20.00
ISBN 978-0-85951-597-9

EXECUTIVE SUMMARY

Radon is the largest and most variable contributor of radiation dose to the general population. For more than twenty years countries in Europe and elsewhere have carried out surveys in order to determine average exposures and identify where excessive exposures occur. Most of these measurements have been carried out using passive etched track radon detectors exposed for periods of months. Activated charcoal and electret radon detectors have also been used, mainly for shorter term measurements. In addition, all three types of detector are used for experimental and research work.

Intercomparisons are essential to ensure that the results of measurements are accurate. By allowing different detectors to be compared side by side an objective assessment of the accuracy of measurements can be made. The results of intercomparisons have been used to identify and rectify problems, as well as providing calibrations for the detectors traceable to international standards.

The Radiation Protection Division of the Health Protection Agency (HPA-RPD), formerly the National Radiological Protection Board (NRPB) carries out international intercomparisons of passive radon detectors each year. Typically around 50 laboratories take part. In each intercomparison laboratories are invited to submit sets of detectors which are randomised into four groups at HPA-RPD. Three of these groups are exposed in the HPA-RPD radon chamber and the fourth group is used to determine transit exposures. Detectors are then returned to the laboratories who are asked to report the result for each detector. Laboratories are not informed of the details of the exposures or which detectors were in which group until all results have been submitted.

This report considers the results for the intercomparison carried out in 2003, for which a total of 49 laboratories from 17 countries submitted 65 sets of detectors. Analysis of the results allows each set to be ranked from A (best) to E (worst). Some sets of etched track, charcoal and electret detectors can be found in each class, demonstrating the point that in measuring radon stringent quality assurance is vital. It is encouraging that a general trend throughout the history of these exercises towards improved results has continued.

The 2003 intercomparison also allowed those laboratories that wished to do so to submit extra detectors for exposure to a simulated cosmic ray field at the CERN-EU high Energy Reference Facility (CERF). It is known that both electret and track etch radon detectors will respond to this type of radiation field, and it was hoped that this exposure might help laboratories to quantify this response. A total of sixteen sets of results were submitted for this exposure, all except for one set of electrets were track etch detectors. The results were somewhat inconclusive, all types of track etch detectors showed a response but this was extremely variable with no obvious reasons for the variability. Further investigation is outside the scope of this study.

International passive radon detector intercomparisons remain popular, with new laboratories joining each year. It is intended to continue these exercises on an annual basis as long as demand for them continues.

CONTENTS

1 INTRODUCTION

Radon is the largest contributor to the radiation dose to the public and is highly variable. Surveys of radon levels in homes and other buildings have been carried out throughout Europe to determine the magnitude of average exposures and to identify situations where excessive exposures occur. The great majority of these surveys have been carried out using passive etched-track detectors exposed over long periods to take account of the short-term variations in radon levels. Some surveys have been carried out using charcoal detectors exposed over periods of a few days, and some have used electrets which may be exposed over periods from days to months.

In order to ensure the quality of these measurements, it is important to compare different detectors exposed side by side. Although passive radon measurement techniques are simple in principle, it has been found that it is difficult in practice to maintain good quality control. The Radiation Protection Research Programme of the European Commission provided funds for intercomparisons of active and passive radon and radon decay product measurement techniques in 1982, 1984 and 1987 (Miles, 1988). More limited exercises were held in 1989 (Miles, 1990), 1991 (Whysall, 1996) and 1995 (Miles, 1996) for passive radon detectors only. Since 1997 these exercises have been conducted on an annual basis (Naismith et al, 1998; Howarth and Miles, 2000a; 2000b; 2002a; 2002b; 2003). Many laboratories regard such an exercise as an important check on the international comparability of radon measurement results and on their quality control procedures.

In 1996 agreement was obtained from the European Commission to sponsor a series of three annual intercomparisons to be held at NRPB. The contract also provided for a steering meeting to be held before the first intercomparison and a final meeting open to all participants to be held after the last of the three. The steering meeting took place in early 1997, followed by intercomparisons in 1997, 1998 and 1999. The final meeting, to which all participants in the intercomparisons were invited was held at NRPB in May 1999.

Participants in the final meeting were invited to complete a questionnaire about future intercomparisons, approximately half of whom did so. The original meeting had decided that the intercomparisons should have two similar exposures and one very different one. The purpose of having two similar exposures was to make the intercomparison more ‘blind’- if three very different exposures are used it is easier for participants to identify which detectors were exposed together. A majority of respondents to the final questionnaire were in favour of having three very different exposures as this would enable participants to use them as a linearity check. This was therefore the format adopted for subsequent intercomparisons.

Forty - nine laboratories submitted 65 sets of passive detectors to this intercomparison. After exposure to radon and its decay products, the detectors were returned to their originating laboratories for assessment. Participants reported the estimated exposure for each detector before they were notified of the exposures given to the detectors. The intercomparison included three laboratory exposures at different equilibrium factors.

2 EXPOSURE AND MEASUREMENT FACILITIES - NRPB

HPA-RPD maintains a 43 m^3 walk-in radon chamber (Miles and Strong, 1989), shown in Figure 1. The chamber is of the static type: radon is continuously released inside the chamber by radon sources, so there is no need to ventilate the chamber. All of the exposures were carried out in this chamber.

The chamber contains a radon atmosphere which can be varied (and held stable) from around 200 Bq m^{-3} to 8000 Bq m^{-3}, depending on the use of various dry and liquid radium-226 sources. A radon concentration of about 4000 Bq m^{-3} is normally maintained in the chamber, and the concentrations of radon and its decay products are continuously monitored. The aerosol conditions and the equilibrium factor in the chamber are altered as required for different studies and calibrations. Table 1 shows the parameters measured and controlled in the chamber.

Three different values of the equilibrium factor (F) between radon and its decay products were obtained for the three laboratory exposures in the intercomparison. To obtain a high value of F in the chamber, the aerosol generator was used to maintain a high aerosol concentration. This reduces the plate-out of radon decay products onto room surfaces. A low equilibrium factor was obtained by running an electrostatic precipitator to remove aerosols and decay products. By running the precipitator fan at low speed an intermediate equilibrium factor was obtained.

The radon concentration in the chamber was continuously monitored using an ATMOS 12 ionisation chamber. This instrument is normally calibrated every 6 months using a radon gas source obtained from the UK National Physical Laboratory (NPL). Because of a problem with supply of the source a calibration was carried out immediately after the intercomparison using a source supplied by Physikalisch - Technische Bundesanstalt (PTB), Germany. A review of six calibrations of the ATMOS using NPL and PTB sources concluded that the variations in apparent ATMOS sensitivity between different calibrations were within the uncertainties of the calibrations. It was therefore decided to use the average of the six values of sensitivity obtained.

An Alphaguard ionisation chamber was used as a backup radon monitoring instrument. Radon decay products were sampled onto a Millipore AA filter and their concentrations determined using a spectrometry system (Cliff, 1990). All monitored data was automatically transferred to a database. Radon and radon decay product exposures were calculated later.

3 EXPOSURE AND MEASUREMENT FACILITIES – CERF

The CERN-EU high Energy Reference Facility (CERF) is installed in one of the secondary beam lines (H6) from the Super Proton Synchrotron in the North Experimental Area on the CERN Prévessin site. This facility is used to simulate the cosmic ray field found at typical commercial flight altitudes (10-20 km) for the calibration and characterisation of detectors (Mitaroff and Silari, 2001).

A positive hadron beam of momentum 120 GeV/c is stopped in a copper target, 7 cm in diameter and 50 cm in length installed beneath 80 cm of concrete shielding in an irradiation cave. The secondary particles produced at 90º to the beam pass through this roof shield and produce an almost uniform radiation field over an area of 2 x 2 m^2. This area is divided into 16 squares of 50x50 cm, each of which represents a reference exposure location. The dose to the radon detectors was assessed using ten bubble detectors to measure the low energy component of the spectrum ($E \leq 20$ MeV) and a stack of passive bismuth detectors to measure the high energy component ($E \geq 20$ MeV).

4 PASSIVE RADON DETECTORS

Two types of passive etched track radon detector are commonly used, one consisting of a track detector within a closed container, which allows radon-222 to diffuse into it (closed) and the other which consists of naked track-detecting material exposed to the ambient atmosphere (open). The closed detector excludes radon decay products which are present in the ambient atmosphere, and records only those alpha particles generated by the radon entering the container and the decay products formed from it. This form of detector therefore provides a result which is related to the true average radon gas concentration during the time of exposure. In recent years a small number of etched track detector designs which have proven successful have been adopted by laboratories other than those which first developed them, often with some modification.

The open detectors, however, record alpha particles originating from both radon and its decay products in the ambient atmosphere. Their response to radon and its decay products as a function of equilibrium factor, F, depends on the detector material used. Open detectors made from Kodak LR-115 have a sensitivity as a function of F which is intermediate between that of a true radon gas detector and a true Equilibrium Equivalent Radon (EER) detector, being closer to the true radon gas response. Bare CR-39 detectors have a response which depends strongly on F, and are not recommended.

Two types of detector which do not rely on etched tracks were submitted by some laboratories: activated charcoal detectors and electret chambers. The charcoal detectors rely on retaining adsorbed radon for measurement in the originating laboratory. As they must be assessed before the radon they adsorb decays or desorbs, each set was returned at the end of an exposure. Electret radon detectors consist of an air chamber above an electret. Ionisation of air in the chamber by radon gradually discharges the electret. Measurement of the charge on the electret by the issuing laboratory before and after exposure to radon allows the average radon during exposure to be calculated. Because electret radon detectors are also sensitive to gamma and cosmic rays, they are sometimes accompanied by additional detectors sealed in radon-proof bags to allow the gamma and cosmic ray dose-rate to be estimated separately. If such extra detectors are not supplied, the combined gamma and cosmic ray dose rate is estimated on the basis of average gamma ray dose rates and the elevation of the measurement point above sea level.

Forty seven sets of closed and three sets of open etched track detectors were submitted to the intercomparison. Another six sets of charcoal detectors and six sets of electrets were submitted. The laboratories participating in the intercomparison are listed in Table 2, and the characteristics of the detectors submitted are shown in the Appendix.

5 LOGISTICAL ARRANGEMENTS

Participating laboratories were sent sets of 40 labels to attach to their detectors and were asked to send the detectors to NRPB in radon-proof bags if possible. Each label carried a detector number from 1 to 40 and a set number. NRPB assigned the detector numbers 16 to 20 and 36 to 40 to the transit control group and the other 30 numbers at random to one of the three measurement groups. Charcoal and electret detectors were submitted in groups of 15, 20 or 30 rather than 40, using 5 or 10 detectors for each measurement group. No transit controls were used for charcoal detectors. Two laboratories submitting sets of electret detectors provided extra detectors to measure gamma and cosmic ray dose rates.

When a set of detectors was received by NRPB, the detectors were divided up among the four groups and stored in radon-proof bags. The handling of the passive radon detectors during the intercomparison was as follows:

a Sets of 40, 15 or 20 detectors were received from participants.

b If they were not already properly labelled, labels were attached.

c Each set was split into 4 groups of 10 (3 or 4 groups of 5 for charcoal and electret).

d Each group of detectors was sealed in a radon proof bag, which was then sealed inside another radon-proof bag (referred to as double bagging below).

e All bags for exposure 1 were put in a large box, similarly for exposure 2, etc.

f Boxes 1-3 and the box of background detectors were stored in the laboratory, in an average radon concentration of 22 Bq m^{-3}.

g The conditions for exposure 1 were obtained in the chamber.

h The detectors for exposure 1 were taken from the box and set up in plastic trays. Detectors which needed to be mounted on supports were mounted outside the exposure chamber.

i The mounted detectors and those in the trays were taken in to the exposure chamber and the detectors set out on two tables in the centre of the chamber over a period of approximately 5 minutes.

j At the end of the exposure the detectors were taken out of the chamber within approximately 5 minutes and set out on benches in the laboratory to allow radon to diffuse out, except for charcoal detectors which were returned to the originating laboratory immediately, and open detectors which were double-bagged.

k After 3 days the detectors were grouped into sets and double-bagged.

l The procedure was repeated for exposures 2 and 3.

m Three days after the third exposure all of the bags of detectors were collected together and grouped according to the originating laboratory. The bags were opened and each group of detectors was double-bagged, all in together if possible.

For the CERF exposure each laboratory that wished to take part was sent two labels to attach to detectors which were sent to NRPB, again in radon proof bags if possible. On arrival at NRPB these detectors were double bagged and stored in the laboratory until they could be sent for exposure at CERF. The detectors were exposed at CERF in pairs while still in the radon proof bags then immediately returned to NRPB. After return to NRPB the detectors were returned to the originating laboratories for processing as soon as possible.

6 EXPOSURES

The radon exposures were carried out in the radon exposure chamber at NRPB. The appropriate conditions were obtained in the chamber before introducing the detectors. Detectors were placed on or above a table in the centre of the radon chamber (see Figure 2). Open detectors were placed with their sensitive surfaces exposed to the air. Detectors designed to hang in the air were hung from a rod above the table.

The exposures are summarised in Tables 3 and 4 and Figures 3-5. The first exposure was at a high equilibrium factor and lasted 264.2 hours. The second exposure was at a low equilibrium factor for 70.1 hours and the third at an intermediate equilibrium factor for 66.5 hours. The radon and EER concentrations during the exposures are shown in Figures 3-5. The continuously emanating dry sources did not emanate enough radon to achieve a high exposure in a reasonable time, so solutions of radon in water were vented every few days during exposure 1. The effect of this can be seen in Figure 5, where each venting of the sources causes a sudden increase in concentration, followed by a decrease due to the decay of radon. Because the first exposure continued for longer than charcoal detectors are normally exposed, they were removed from the chamber after 4 days and returned to the originating laboratories.

During the exposures the radon level was monitored continuously by the ATMOS 12 instrument. Measurements of radon decay products were made using the alpha particle spectrometric method on 46 occasions during the first exposure, 23 occasions during the second and 19 during the third. The radon concentration in the laboratory outside the exposure chamber was monitored during the exposures using an Alphaguard Professional monitor. The daily average concentrations ranged from 14 to 53 Bq m^{-3}, with an overall average of 22 Bq m^{-3}. The estimated additional exposure of the detectors caused by leaving them exposed in the laboratory for 3 days to allow radon to diffuse out of them was less than 1% of the exposure in the chamber in all cases and was neglected.

Thoron decay product concentrations were estimated by recounting some of the filter papers overnight, 24 hours after sampling. The highest thoron decay product concentration was found to be <1 Bq m^{-3} equilibrium equivalent thoron during exposure 1. Temperature and humidity did not vary greatly during the exposures. Figure 6 gives the variation during exposure 2 as an example.

The simulated cosmic ray exposure was carried out at CERF. All of the detectors were exposed simultaneously in pairs without removing them from their radon proof bags. This eliminated any need for radon monitoring during the exposure. Each pair was placed on the concrete shielding above the copper target with the detector element normal to the radiation field if possible. Monitoring of the field was carried out using two methods (Nava et al, 1997). The low energy component of the neutron spectrum (E<20 MeV) was measured using ten different bubble detectors. For the high energy component (>20 MeV) the dose was measured using a stack of passive bismuth fission track detectors (Curzio et al, 2001). The total uncertainty on the dose values measured is less than 20%, and corresponds well with the dose predicted by the Monte Carlo calculations using the FLUKA code. The total dose to the detectors was 34.0 ± 2.4 mSv.

7 RESULTS AND DISCUSSION

Each participant was asked to return results for each detector in terms of kBq m^{-3} h exposure of radon. The results were received by NRPB before the participants were informed of the exposures given. With the exception of the charcoal detectors (which had to be returned immediately at the end of an exposure), participants did not know which detectors were exposed together. To ensure that the results submitted by NRPB (as a participant in the intercomparison) were reported blind as well, they were routed through a third party who renumbered the detectors. The exposures given in the intercomparison were not calculated until after the results for NRPB detectors had been returned and the deadline for return of all results had been passed.

Results were submitted for 62 out of the 65 sets of detectors. Results for three sets were not received for a variety of reasons, mainly to do with doubts regarding calibrations. A summary of the results is given in Table 5 and Figures 8-11. The mean of the transit exposure results for a set of detectors was subtracted from all other results for that set before calculating the means and standard deviations. Note that in the tables, standard deviations are given as a measure of the spread of a set of results. In the figures the error bars shown are standard errors on each set of results to show whether differences between mean results and the reference levels can be accounted for by variations within a set.

As in the previous four intercomparisons, the sets of detectors were ranked in an additional table (Table 6). The mean absolute percentage difference and the mean standard deviation between the reported result and the reference value were calculated separately for each set. Sets which recorded <10% for both difference and SD were ranked as category A, sets <15% for both as category B, sets <20% as category C, sets

<25% as category D and others as category E. Within each category, sets are ordered using the sum of the mean percentage difference from the reference exposure and the mean percentage standard deviation.

Two sets of electrets, all six sets of charcoal detectors and 17 sets of etched track detectors achieved the category A rating. All of the sets of etched track detectors in category A are closed, and most use one of the standard designs of holder. The general trend of improvement in the results observed since the 1997 intercomparisons seems to have reached a plateau. A comparison of this table with the equivalent in the reports of recent intercomparisons shows that the number of laboratories achieving results in the top category, A, seems to have stabilised in the region of 40-45%. However, the number with results in the lowest category has increased from 14% to 22%. The median values of the percentage differences and percentage standard deviations found in the three exposures were: for the lowest exposure 9 and 10; for the next exposure 9 and 9; and for the highest exposure 10 and 5.

Two additional conclusions can be drawn from the data, though not obvious from the tables. Almost all of the best etched track detector results were obtained using small detector holders (about 2 cm high) and most used electrically conducting holders to prevent electrostatic charges on the holder from affecting the deposition of decay products. It is therefore encouraging that during recent intercomparisons there has been a marked trend towards the use of standard small closed conducting holders among the participants.

It should be noted that errors of bias can in principle be corrected by more accurate calibration, but if there is a large standard deviation on a set of detectors exposed simultaneously this indicates problems which may be more difficult to identify and correct. There are many potential sources of error on individual results, including the effects of shock in partially discharging electrets and problems of proper recognition of etched tracks by automatic image analysers.

Table 7 shows the minimum standard deviations achieved by each of the common detector types, taking the last seven (1997-2003) intercomparisons together. These results serve as reference points for each of the detector types. In all cases there were other laboratories using the same combination of holder and detector material which produced much higher standard deviations. The results demonstrate that many laboratories are not achieving the best possible results from their detectors. They also appear to show differences between the best possible results obtainable from each detector type.

As can be seen from Table 2, large numbers of European and other laboratories continue to take part in these passive detector intercomparisons. Although the slightly different format for this intercomparison and the exercise in 2000 makes comparison with previous years difficult, there has been a general trend of improvement in results which it is hoped will continue. These improvements can be attributed to several factors. One of the most important is for participants to see their results ranked alongside those from other laboratories, so that they can tell immediately whether they are performing better or worse than others. Poor performance provides a strong incentive for improvement. Also the nature of the errors shown by the results allows a participant to identify what may be going wrong. For instance, high standard deviations indicate poor quality control, and possibly electrostatic effects. Consistent deviations from the reference value indicate a calibration error. Variable deviations from the reference value may indicate non-linearity of response. Hence participation in an intercomparison like the one reported here allows a scientist to identify and correct sources of error.

Due to the etching processes used, etched track detectors optimised for radon monitoring generally have a poor response to neutrons, particularly those which do not use an electrochemical etching technique. Damage trails resulting from (n,p) capture reactions are usually smaller than those from alpha particles and therefore harder to detect. The radiation field used in the CERF exposure has a large high energy component (<100 MeV) which can interact with the detector material via spallation. This process produces a number of products, including alpha particles of approximately 5 MeV which produce damage trails that are effectively identical to those resulting from radon gas and radon daughter decay.

As described above, detectors were exposed in pairs. Results were analysed in terms of radon equivalent exposure per millisievert (kBq h m^{-3} mSv^{-1}). Figure 12 shows the range of results for each pair, with the bars showing the upper and lower values for each pair. As can be seen from the figure some pairs produced very similar individual results while others showed a more variable response. Table 8 summarises the results for each pair of detectors. It appears that there is no obvious pattern of response for the detectors to the neutron field. For instance, the detector pair with the second lowest response (13-1) and the detector pair with the highest (136-1) are the same design of holder and use the same detector material, although they are from different laboratories. One item of note is that in cases where a single laboratory has submitted two pairs of the same type of detector there is a close correspondence between the two pairs. The reasons for this, however, remain unclear.

The results for this exposure show that etched track detectors designed and optimised for area monitoring of radon will respond to a radiation field similar to that found at commercial flight altitudes. The wide and apparently random nature of that response indicates that it is a product of a number of subtle variables which are specific to individual detector designs and laboratory practices. Further investigation of this phenomenon is therefore probably a matter for individual laboratories.

8 ACKNOWLEDGEMENTS

The authors would like to thank Richard Algar, Keith Birch and Zeinub-Ferozan Ibrahimi who provided valuable assistance in the radon exposure of the detectors. They would also like to thank Luigi Tommassino (ANPA, Italy) and Marco Silari (CERF) for arranging and carrying out the neutron exposures.

9 REFERENCES

Cliff KD (1990). UK National Radiological Protection Board radon calibration procedures. *J National Institute of Standards and Tech,* **95**, 135-138.

Curzio G, Grillmaier RE, O'Sullivan D, Pellicioni M, Piermattei S, Tommassino L (2001). The Italian national survey of aircrew exposure: 1. Characterisation of advanced instrumentation. *Radiat Prot Dosimetry,* **93**, 115-123.

Howarth CB and Miles JCH (2000a). Results of the 1998 European Commission intercomparison of passive radon detectors. EUR 18835 EN. CEC, Luxembourg.

Howarth CB and Miles JCH (2000b). Results of the 1999 European Commission intercomparison of passive radon detectors. EUR 19148 EN. CEC, Luxembourg.

Howarth CB and Miles JCH (2002). Results of the 2000 NRPB intercomparison of passive radon detectors. Chilton, NRPB-W6

Howarth CB and Miles JCH (2002b). Results of the 2001 NRPB intercomparison of passive radon detectors. Chilton, NRPB-W21

Howarth CB and Miles JCH (2003). Results of the 2002 NRPB intercomparison of passive radon detectors. Chilton, NRPB-W44

Miles JCH and Olast M (1990). Results of the 1989 CEC intercomparison of passive radon detectors. Chilton, NRPB-M251.

Miles JCH and Strong JC (1989). Radon calibration facilities at NRPB. Radiological Protection Bulletin 104, 6.

Miles JCH, Algar RA, Howarth CB, Hubbard LM, Risica S, Kies A and Poffijn A (1996). Results of the 1995 European Commission intercomparison of passive radon detectors. EUR 16949 EN. CEC, Luxembourg.

Miles, JCH and Sinnaeve, J (1988). The value of intercomparisons in radon metrology. *Radiat Prot Dosimetry* **24**, 313-316.

Mitaroff A and Silari M (2001). The CERN-EU high-energy Reference Field (CERF) facility for dosimetry at commercial flight altitudes and in space. CERN-TIS-2001-006-RP-PP. CERN, Switzerland

Naismith SP, Howarth CB and Miles JCH (1998). Results of the 1997 European Commission intercomparison of passive radon detectors. EUR 18035 EN. CEC, Luxembourg.

Nava E, Otto T and Silari M (1997). Reference dose equivalent values for the 1997 CERN-EC runs. CERN-TIS-RP/TM/97-22. CERN, Switzerland.

NPL (1973). A code of practice for the detailed statement of accuracy. HMSO, London.

Rancati T and Ferrari A. Personal Communication (1996).

Whysall K, Miles JCH and Olast M (1996). Results of the 1991 CEC Intercomparison of Passive Radon Detectors. EUR 15156 EN. CEC, Luxembourg.

10 TABLES AND FIGURES

Table 1 Parameters measured and controlled in the HPA-RPD radon chamber

Parameter	Control	Measurement
Temperature	None	Platinum resistance thermometer
Humidity	Humidifier and dehumidifier controlled by humidistats.	Capacitive sensor
Aerosol concentration	Carnauba wax aerosol generator, electrostatic precipitator	Ultrafine condensation nucleus counter (TSI 3025)
Aerosol size distribution	Aerosol about 100 nm produced by aerosol generator	Diffusion battery with switching valve
Radon concentration	Dry and liquid radium sources	Ionisation chambers (Atmos 12 DPX and Alphaguard Professional)
Radon decay product concentrations	Use of aerosol generator, electrostatic precipitator with variable speed fan and mixing fans	Sampling on Millipore AA filter, spectrometry using Nazaroff method
Unattached fraction	As for radon decay product concentrations	Sampling on wire screen
Active aerosol size distribution	As for radon decay product concentrations	Six channel parallel diffusion battery

Table 2 Laboratories participating in the intercomparison

Name	Organisation	Country
A Canoba	Nuclear Regulatory Authority	Argentina
Dr J Paridaens	SCK/CEN	Belgium
J Andru	Dosirad	France
A Rox	MPA-NRW	Germany
S Ugi	Karlsruhe Research Centre	Germany
T R Beck	BfS	Germany
E Hulber	Elektronika 77, Ltd.	Hungary
I Csige	Institute of Nuclear Research	Hungary
Dr D Fenton	RPII	Ireland
Dr N Levi	Environmental Services Co.	Israel
A Parravicini	MI.AM srl	Italy
Dr A Bertolo	ARPAV Dipartimento di Padova	Italy
Dr C Cazzato	Esp. Qualificato di III Grado	Italy
Dr C Sabbarese	Seconda Università di Napoli	Italy
Dr L Gaidolfi	ARPA - Sezione di Piacenza	Italy
Dr L Salvatori	FGM Ambiente	Italy
Dr L Verdi	Agenzia Provinciale Protezione Ambiente	Italy
Dr R Trevisi	Centro Ricerche ISPESL	Italy
Dr S Arrigoni	ARPA Lombardia	Italy
Dr S Rullo	GAIA Consulting and technologies S.r.l.	Italy
F Trotti	CRR-ARPAV	Italy
G Torri	ANPA	Italy
M Calamosca	ENEA IRP	Italy
M Magnoni	ARPA Piemonte. Dip. Ivrea	Italy
S Pividore	MCF snc	Italy
Dr S Tokonami	National Institute of Radilogical Sciences	Japan
Dr T Sanada	Japan Chemical Analysis Centre	Japan
G Morkunas	Radiation Protection Centre	Lithuania
Aleksandar Birovljev	National Institute of Technology	Norway
Dr Bente Fjerdingen	Rödmyr Miljösenter	Norway
Dr T Bertheussen	RADONLAB	Norway
K Ånestad	NRPA	Norway
D Kluszczynski	Institute of Occupational Medicine	Poland
Dr P Duarte	ITN/DPSRN	Portugal
M Al-Jarallah	King Fahd Univ.of Pet. And Min.	Saudi Arabia
M Vicanova	Institute of Preventive and Clinical Medicine	Slovak Republic
Peter Jovanovic	ZVD.dd.	Slovenia
J Armas	Universidad de la Laguna	Spain
Dr A Diebitsch	Independia Control AB	Sweden
Frej Kullman	MRM Konsult AB	Sweden
Mats Isaksson	Su / Sahlgrenska	Sweden
Nils Hagberg	SSI	Sweden
Tryggve Rönnqvist	Gammadata Mätteknik AB	Sweden
B H Ahern	Radon - One (UK) Ltd	United Kingdom
J Miles	NRPB	United Kingdom
Mr P Conlon	Euro radon labs	United Kingdom
Phil Gilvin	NRPB Personal Monitoring Services	United Kingdom
Roger Stokes	DRPS	United Kingdom
T Finnigan	Landauer	United Kingdom

Table 3 Air treatment during laboratory exposures

Exposure	1	2	3
Mixing fan	On	On	On
Aerosol generator	On	On	On
Electrostatic precipitator	Off	High	Low

Table 4 Exposure durations and magnitudes

Exposure	1	2	3
Duration (h)	264.17	70.08	66.5
Radon exposure (kBq m^{-3} h)	2290	294	117
Uncertainty (%)*	5	5	5
EER exposure (kBq m^{-3} h)	1969	44	50
Uncertainty (%)*	7	7	7
F	0.86	0.15	0.43

*Estimated uncertainty at 68% confidence level. For radon gas exposure this is estimated from the contributions to uncertainty on measurements with the Atmos 12 instrument: volume of calibration vessel, 3.1%, counting statistics, 3%, radon gas source, 1.5%. Using the standard method of combining these uncertainties (NPL, 1973) yields a total uncertainty of 4.6% rounded to 5%. The method of estimating uncertainty on radon decay product measurements is given by Cliff (1990).

Notes to Tables 5, 6 and 7

1. The results for sets 48 - 1, 49 - 1, 127 - 1, 132 - 1, 132 - 2, 132 - 3 are for charcoal detectors which were exposed separately for exposure 2. The reference result for these detectors is 977 kBq m^{-3} h. In Figure 11 these results are normalised to a reference value of 2290, for comparison with other detector sets.
2. Results for sets 29 - 1 and 94 - 1 were received after the exposure details had been released.
3. The set numbers were chosen randomly and do not follow the order of laboratories in Table 2.
4. The transit group is the group of 10 detectors returned unexposed.
5. The mean result for exposed detectors is the mean after subtracting the mean transit exposure.
6. % SD is the percentage standard deviation.
7. % Diff is the percentage difference between the reference value and the mean reported.
8. In Table 6 the Mean % diff and Mean % SD are the means of the three absolute values given for a set in Table 5.
9. In Table 6, ‘Sum’ is the sum of Mean % diff and Mean % SD.

Table 5 Radon results from passive detectors (kBq m^{-3} h)

	Transits		Exposure 1			Exposure 2			Exposure 3		
Set ID	Mean	SD	Mean	% Diff	%SD	Mean	% Diff	%SD	Mean	% Diff	%SD
1 - 1	1.60	1.90	2555.40	11.59	2.77	294.00	0.00	9.66	111.80	-4.44	8.53
2 - 1	67.89	88.69	2737.61	19.55	47.48	312.71	6.36	63.85	116.01	-0.85	110.48
7 - 1	23.30	4.27	2076.70	-9.31	5.85	307.00	4.42	11.87	116.40	-0.51	10.37
7 - 2	38.20	11.26	2380.60	3.96	5.82	313.60	6.67	9.54	127.10	8.63	12.66
10 - 1	8.00		2006.90	-12.36	0.32	269.70	-8.27	2.06	102.00	-12.82	55.54
12 - 1	4.20	1.14	2406.80	5.10	1.03	292.20	-0.61	1.57	106.50	-8.97	2.80
13 - 1	6.60	5.89	2301.20	0.49	1.58	272.20	-7.41	4.46	108.60	-7.18	5.79
14 - 1	19.80	6.73	2283.40	-0.29	3.62	335.50	14.12	9.09	126.80	8.38	19.24
15 - 1	2.40	6.17	2073.50	-9.45	9.61	275.00	-6.46	17.00	111.40	-4.79	22.17
15 - 2			2358.60	3.00	3.66	316.00	7.48	6.44	121.60	3.93	8.70
16 - 1	23.60	3.89	2786.30	21.67	3.31	356.90	21.39	2.54	138.50	18.38	8.11
16 - 2	33.90	12.74	2668.30	16.52	2.07	369.10	25.54	6.05	150.70	28.80	8.44
17 - 1			2417.10	5.55	2.13	257.10	-12.55	10.59	113.90	-2.65	12.22
18 - 1	2.80	1.87	2322.60	1.42	3.23	300.70	2.28	10.26	131.70	12.56	10.30
18 - 2	2.80	1.81	2304.90	0.65	3.09	318.70	8.40	9.36	134.00	14.53	10.39
19 - 1	13.40	10.38	2378.70	3.87	7.28	288.40	-1.90	12.70	107.10	-8.46	14.21
23 - 1	9.10	5.45	2102.70	-8.18	13.04	270.00	-8.16	7.28	111.40	-4.79	13.12
25 - 1			2012.40	25.07	1.77	232.50	-20.92	5.40	106.60	-8.89	9.19
25 - 2			2239.10	-2.22	2.53	309.20	5.17	3.89	115.80	-1.03	11.19
26 - 1	20.00	4.47	2357.10	2.93	1.78	328.10	11.60	3.26	117.40	0.34	4.97
27 - 1	38.50	5.69				271.50	-7.65	2.55	102.30	-12.56	6.27
28 - 1	10.80	5.43	2050.10	-10.48	12.02	286.20	-2.65	12.70	113.40	-3.08	20.33
28 - 2	39.30	13.55	2294.40	0.19	12.36	331.00	12.59	40.26	178.80	52.82	60.11
29 - 1	403.90	130.55	1612.70	-29.58	16.51	1332.90	353.37	67.26			
31 - 1	6.10	3.60	2021.80	-11.71	10.02	261.60	-11.02	15.29	127.20	8.72	9.32
32 - 1	8.10	4.58	2745.20	19.88	3.09	351.90	19.69	4.16	142.50	21.79	11.79
33 - 1	1.20	1.62	267.58	-88.32	14.94	31.05	-89.44	15.08	10.24	-91.24	9.90
39 - 1	18.20	2.70	2333.90	1.92	1.11	288.00	-2.04	3.90	112.40	-3.93	7.46
40 - 1	4.20	1.03	2767.50	20.85	4.61	301.10	2.41	7.84	120.30	2.82	9.12
42 - 1	12.60	1.07	2155.90	-5.86	3.25	268.50	-8.67	3.62	114.70	-1.97	4.01
48 - 1			836.60	-14.37	0.81	298.60	1.56	1.83	108.00	-7.69	1.85
49 - 1			977.00	0.00	2.95	274.20	-6.73	4.19	92.00	-21.37	1.88
66 - 1	23.70	8.68	2277.10	-0.56	6.27	270.70	-7.93	10.06	109.90	-6.07	8.98
68 - 1	101.50	54.19	2592.70	13.22	71.34	412.50	40.31	78.95	255.00	117.95	51.00
73 - 1	72.30	36.37	2064.60	-9.84	14.80	346.30	17.79	15.48	107.30	-8.29	44.12
76 - 1			2398.33	4.73	6.67	266.50	-9.35	42.84	243.40	108.03	157.57
83 - 1	29.30	13.11	2559.00	11.75	5.45	416.90	41.80	11.18	134.30	14.79	16.59
86 - 1	48.40	8.30	1687.90	-26.29	12.65	165.40	-43.74	8.68	55.80	-52.31	31.78
94 - 1	41.90	8.37	2331.70	1.82	7.48	325.00	10.54	11.81	125.40	7.18	12.96
94 - 2	60.70	22.20	2650.40	15.74	11.47	319.80	8.78	16.46	119.70	2.31	16.31
116 - 1	24.70	2.06	2172.20	-5.14	1.96	270.40	-8.03	3.16	115.30	-1.45	4.72
117 - 1	50.90	10.21	2781.80	21.48	4.84	353.40	20.20	6.56	144.90	23.85	6.22
117 - 2	59.10	12.96	2805.20	22.50	4.39	359.20	22.18	7.01	145.60	24.44	8.58
122 - 1	206.70	603.40	1637.80	-28.48	33.47	41.90	-85.75	145.02	-72.30	-161.79	-90.32
123 - 1	72.50	89.85	2713.50	18.49	11.68	246.40	-16.19	35.11	86.90	-25.73	72.30

	Transits		Exposure 1			Exposure 2			Exposure 3		
Set ID	Mean	SD	Mean	% Diff	%SD	Mean	% Diff	%SD	Mean	% Diff	%SD
125 - 1	60.70	16.97	2744.60	19.85	6.88	339.60	15.51	5.69	165.50	41.45	36.98
127 - 1			810.00	-17.09	7.41	300.00	2.04	6.67	110.00	-5.98	14.55
127 - 2									134.40	14.87	1.45
128 - 1	273.75	336.67	3633.65	58.67	11.96	216.55	-26.34	78.78	-61.53	-152.59	-269.04
129 - 1	-1.90	7.29	2162.30	-5.58	4.80	282.50	-3.91	11.92	109.50	-6.41	4.74
129 - 2	1.90	8.97	2092.20	-8.64	6.08	279.40	-4.97	9.45	105.30	-10.00	9.56
130 - 1	6.10	4.82	2117.00	-7.55	4.52	290.40	-1.22	5.86	109.90	-6.07	5.17
132 - 1			884.75	-9.44	2.56				110.33	-5.70	3.77
132 - 2			872.00	-10.75	3.67				108.00	-7.69	2.78
132 - 3			881.00	-9.83	2.09				115.33	-1.42	6.51
133 - 1			2239.80	-2.19	3.93	256.20	-12.86	17.87	215.00	83.76	65.77
134 - 1			2260.00	-1.31	0.78	317.80	8.10	7.12	117.60	0.51	8.95
135 - 1	53.00	51.81	2434.70	6.32	105.78	430.20	46.33	71.34			
136 - 1	23.40	3.66	2808.50	22.64	4.07	356.60	21.29	4.91	144.10	23.16	7.43
137 - 1	26.30	7.33	2259.70	-1.32	12.09	313.10	6.50	14.11	123.30	5.38	15.37
137 - 2	45.20	13.24	2681.30	17.09	2.35	384.40	30.75	9.73	177.20	51.45	52.70
139 - 1	1.90	2.18				244.20	-16.94	4.79	100.60	-14.02	18.56
Reference value			2290			294			117		

Table 6 Results ranked by category

Rating	Set ID	Mean % diff	Mean % SD	Sum	Type	Filter	Holder	Detector material
A	12 - 1	4.90	1.80	6.70	Closed		NRPB/SSI	CR39
A	39 - 1	2.63	4.16	6.79	Closed		NRPB/SSI	CR39
A	116 - 1	4.87	3.28	8.15	Closed		NRPB/SSI	CR39
A	26 - 1	4.96	3.34	8.29	Closed	Yes	Own	Makrofol
A	25 - 2	2.81	5.87	8.68	Closed		Own	LR115
A	134 - 1	3.31	5.62	8.92	Closed		E perm (S)	Electret
A	13 - 1	5.03	3.94	8.97	Closed		NRPB/SSI	CR39
A	42 - 1	5.50	3.62	9.12	Closed		RAD/E77	CR39
A	48 - 1	7.88	1.50	9.37	Open		Canister	Charcoal
A	132 - 3	5.63	4.30	9.92	Open		Canister	Charcoal
A	130 - 1	4.95	5.18	10.13	Closed		RAD	CR39
A	132 - 1	7.57	3.17	10.74	Open		Canister	Charcoal
A	15 - 2	4.80	6.26	11.07	Closed		E Perm (S)	Electret
A	1 - 1	5.34	6.99	12.33	Closed		NRPB	CR39
A	49 - 1	9.37	3.01	12.38	Open		Canister	Charcoal
A	132 - 2	9.22	3.23	12.45	Open		Canister	Charcoal
A	129 - 1	5.30	7.16	12.45	Closed		Own	CR39
A	66 - 1	4.85	8.43	13.29	Closed		KfK A	Makrofol
A	18 - 1	5.42	7.93	13.35	Closed		KfK FN	Makrofol
A	7 - 1	4.75	9.36	14.11	Closed		Own	LR115
A	17 - 1	6.92	8.31	15.23	Closed	Yes	Own	CR39
A	18 - 2	7.86	7.61	15.47	Closed		KfK FN	Makrofol
A	7 - 2	6.42	9.34	15.76	Closed		NRPB/SSI	CR39
A	40 - 1	8.70	7.19	15.88	Closed		NRPB	CR39
A	129 - 2	7.87	8.36	16.23	Closed		Own	CR39
A	127 - 1	8.37	9.54	17.91	Closed	Yes	Picorad	Charcoal
B	27 - 1	10.11	4.41	14.52	Closed		E-Perm (S)	Electret
B	19 - 1	4.75	11.40	16.14	Closed		ANPA	LR115
B	127 - 2	14.87	1.45	16.32	Closed		Eperm(S)	Electret
B	94 - 1	6.51	10.75	17.27	Closed		ANPA	LR115
B	23 - 1	7.04	11.15	18.19	Closed		NRPB/SSI	CR39
B	14 - 1	7.59	10.65	18.24	Closed		NRPB/SSI	CR39
B	137 - 1	4.40	13.86	18.26	Closed		ANPA	LR115
B	31 - 1	10.48	11.55	22.03	Open		Own	LR115
B	94 - 2	8.94	14.75	23.69	Closed		RAD	CR39
C	28 - 1	5.40	15.02	20.42	Closed		ANPA	LR115
C	15 - 1	6.90	16.26	23.16	Closed		ANPA	LR115
C	25 - 1	18.29	5.46	23.75	Open		Own	LR115
C	139 - 1	15.48	11.67	27.15	Closed	Yes	Own	Makrofol
C	10 - 1	11.15	19.31	30.46	Closed		NRPB/SSI	CR39

Table 6 Results ranked by category (continued)

D	16 - 1	20.48	4.65	25.13	Closed		RAD	CR39
D	32 - 1	20.46	6.35	26.80	Closed		NRPB/SSI	CR39
D	117 - 1	21.84	5.88	27.72	Closed		RAD	CR39
D	136 - 1	22.37	5.47	27.84	Closed		NRPB/SSI	CR39
D	16 - 2	23.62	5.52	29.14	Closed		Own	CR39
D	117 - 2	23.04	6.66	29.70	Closed		Own	CR39
D	83 - 1	22.78	11.07	33.85	Closed		KfK A	Makrofol
D	73 - 1	11.97	24.80	36.77	Closed		NRPB	CR39
E	125 - 1	25.60	16.52	42.12	Closed		Radosys	CR39
E	137 - 2	33.10	21.59	54.69	Closed		Own	CR39
E	86 - 1	40.78	17.70	58.48	Closed	Yes	Own	CR39
E	28 - 2	21.87	37.58	59.44	Closed		RAD	CR39
E	123 - 1	20.14	39.70	59.83	Closed		Own	CR39
E	133 - 1	32.94	29.19	62.12	Closed		Eperm(L)	Electret
E	2 - 1	8.92	73.94	82.86	Closed		NRPB/SSI	CR39
E	33 - 1	89.67	13.31	102.97	Open		Own	LR115
E	76 - 1	40.71	69.03	109.73	Closed		Eperm (S)	Electret
E	135 - 1	26.32	88.56	114.88	Closed		ANPA	LR115
E	68 - 1	57.16	67.09	124.25	Closed		KfK A	Makrofol
E	122 - 1	92.01	89.60	181.61	Closed		RAD/E77	CR39
E	128 - 1	79.20	119.92	199.13	Closed		RAD/E77	CR39
E	29 - 1	191.47	41.89	233.36	Closed	Yes	Own	CR39

Table 7. Minimum standard deviations achieved by different common detector types in the last five intercomparisons.

Holder	Detector material	Minimum mean % SD
Canister	Activated charcoal	1.0
E-Perm L	Electret	2.3
NRPB/SSI	CR-39/PADC	2.7
Karlsruhe FN	Polycarbonate	4.3
NRPB	CR-39/PADC	4.6
ANPA	Cellulose nitrate	4.7

Note: Measuring laboratories were not aware which detectors were exposed together to the same radon level, except in the case of activated charcoal detectors, which had to be returned immediately at the end of each exposure to avoid excessive loss of absorbed radon by decay.

Table 8 Results for detectors exposed at CERF

Set ID	Detector type	Detector material	Mean observed result kBq m^{-3} h	Dose (mSv)	Response kBq m^{-3} h mSv^{-1}
1 - 1	NRPB	CR39	313	34.0	9.2
7 - 1	Own	LR115	364.5	34.0	10.7
7 - 2	NRPB/SSI	CR39	1142.5	34.0	33.6
13 - 1	NRPB/SSI	CR39	285	34.0	8.4
14 - 1	NRPB/SSI	CR39	830.5	34.0	24.4
16 - 1	RAD	CR39	524	34.0	15.4
16 - 2	Own	CR39	601	34.0	17.7
40 - 1	NRPB	CR39	626	34.0	18.4
66 - 1	KfK A	Makrofol	303	34.0	8.9
94 - 1	ANPA	LR115	1268.5	34.0	37.3
94 - 2	RAD	CR39	304	34.0	8.9
123 - 1	Own	CR39	290.5	34.0	8.5
129 - 1	Own	CR39	455	34.0	13.4
129 - 2	Own	CR39	356	34.0	10.5
134 - 1	Eperm (S)	Electret	119.5	34.0	3.5
136 - 1	NRPB/SSI	CR39	1350.5	34.0	39.7

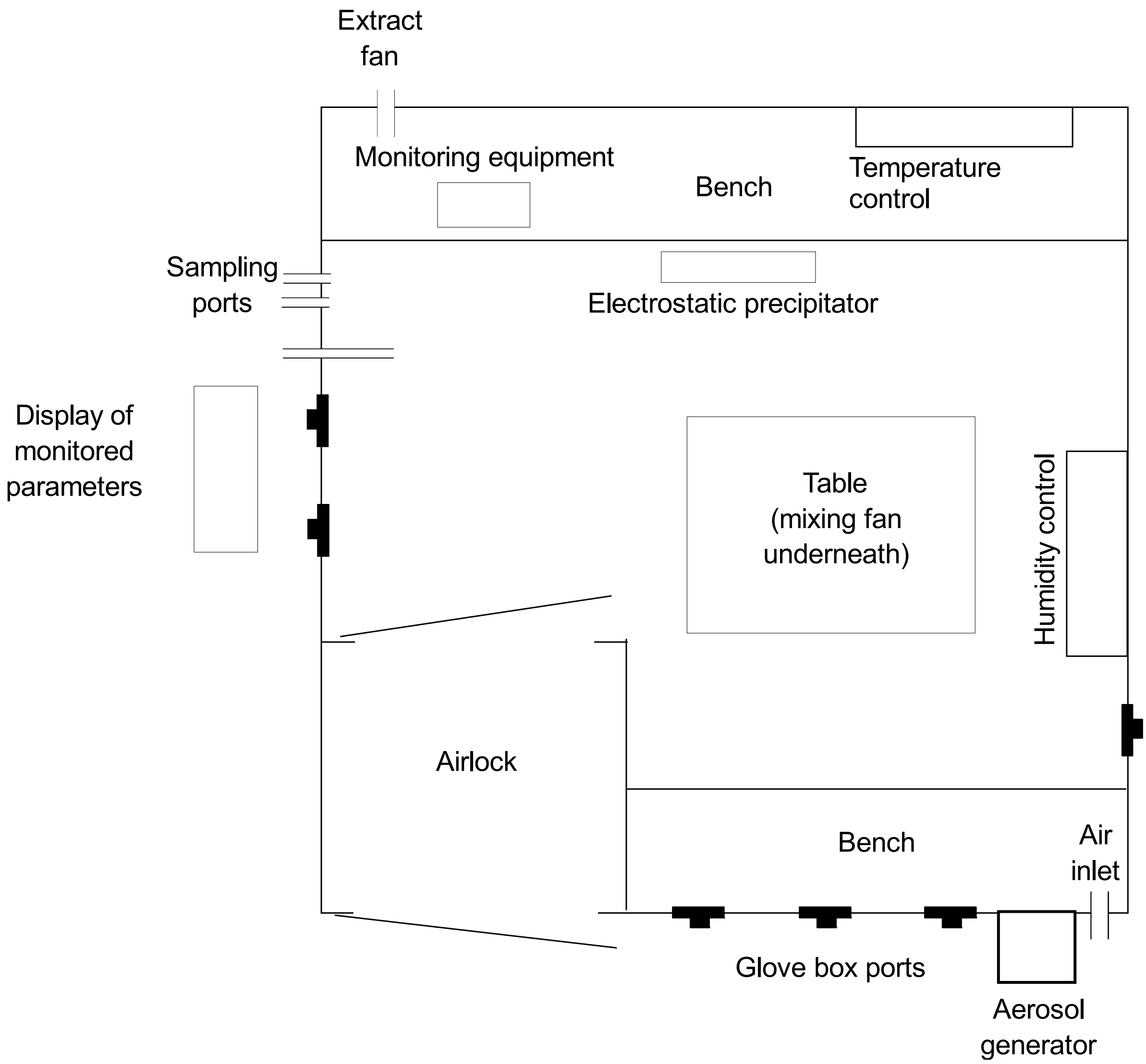


Figure 1 the HPA-RPD radon chamber

Figure 2 Detectors during an exposure

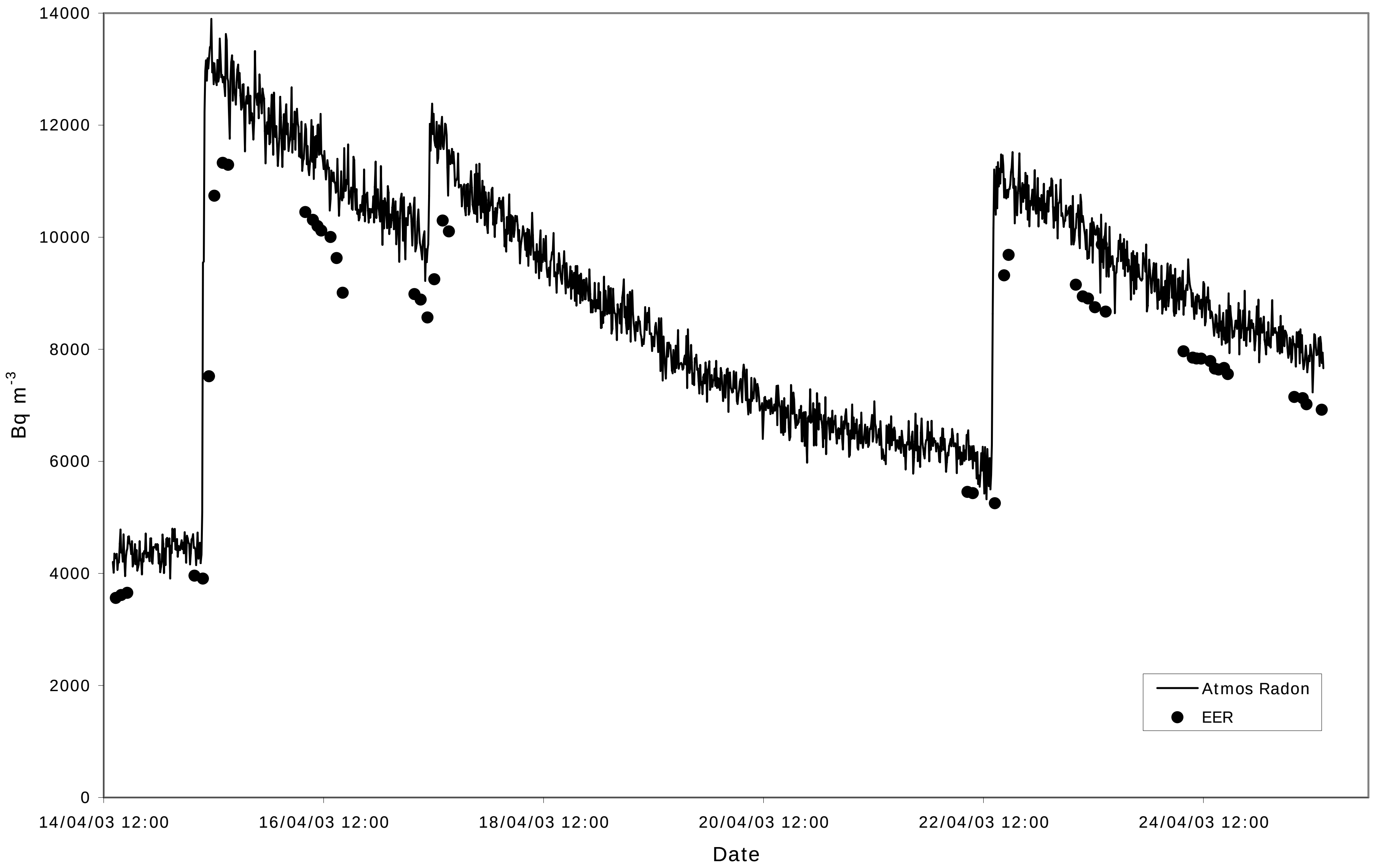


Figure 3 Radon and Equilibrium Equivalent Radon (EER) concentrations exposure 1

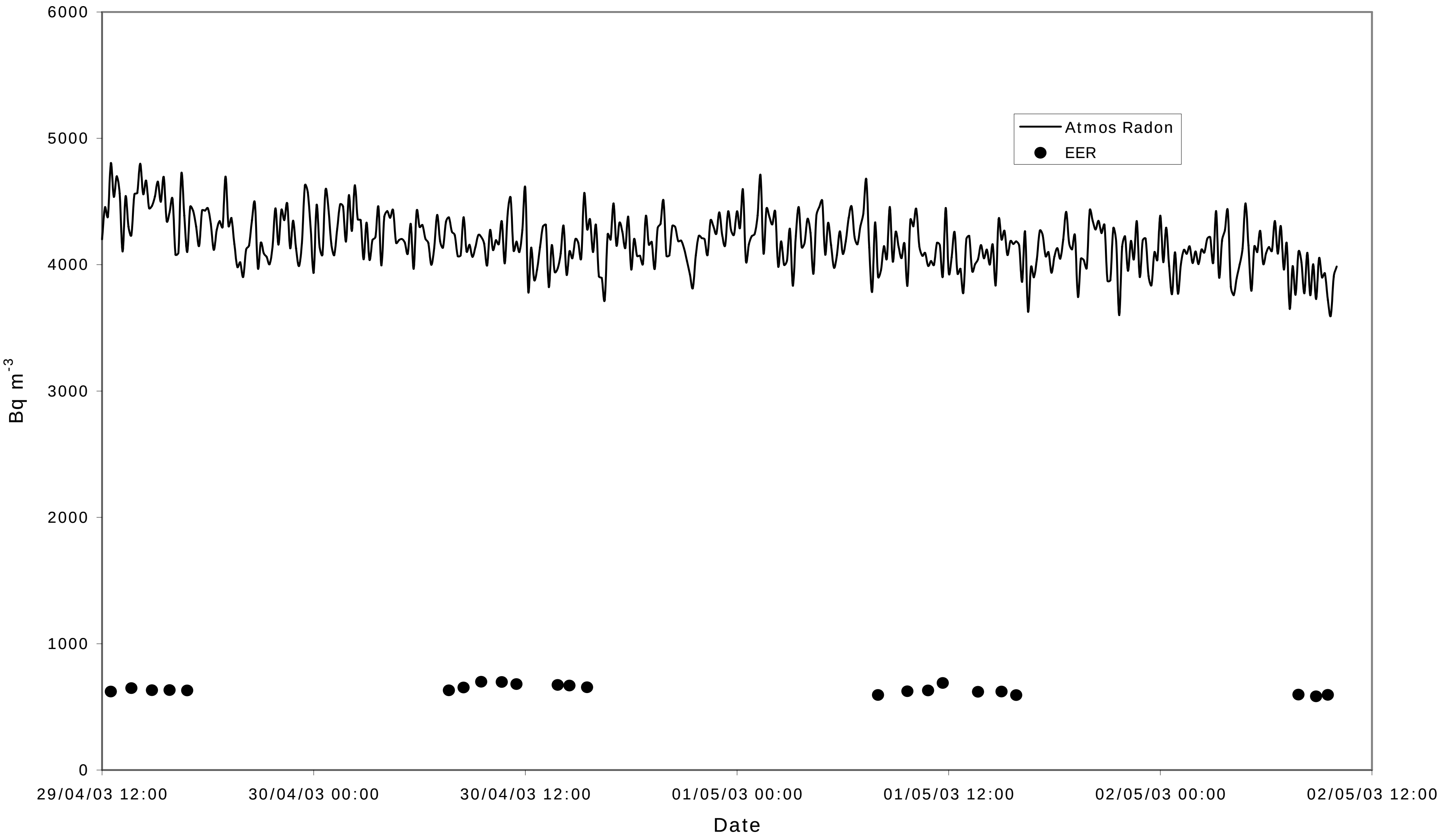


Figure 4 Radon and Equilibrium Equivalent Radon (EER) concentrations exposure 2

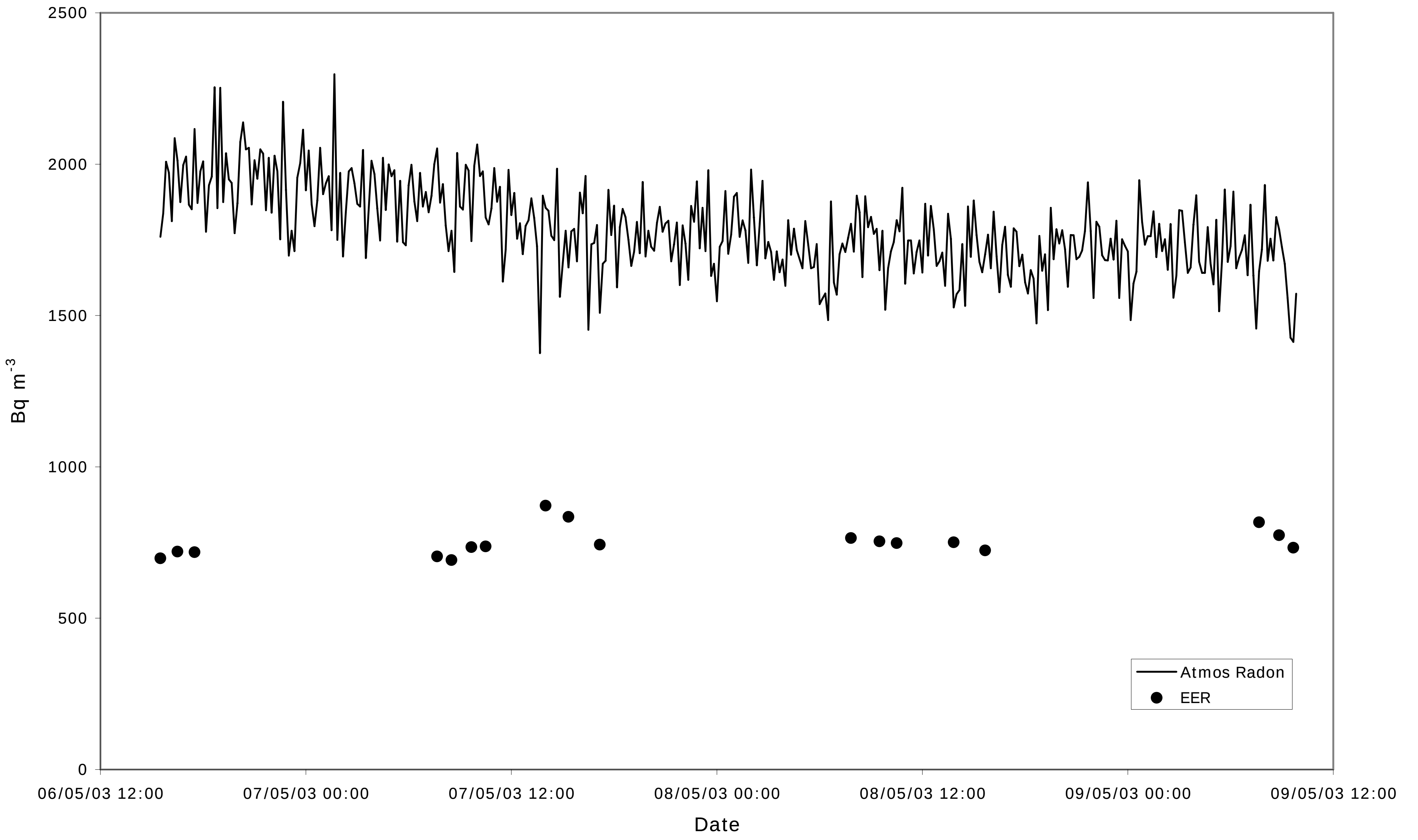


Figure 5 Radon and Equilibrium Equivalent Radon (EER) concentrations exposure 3

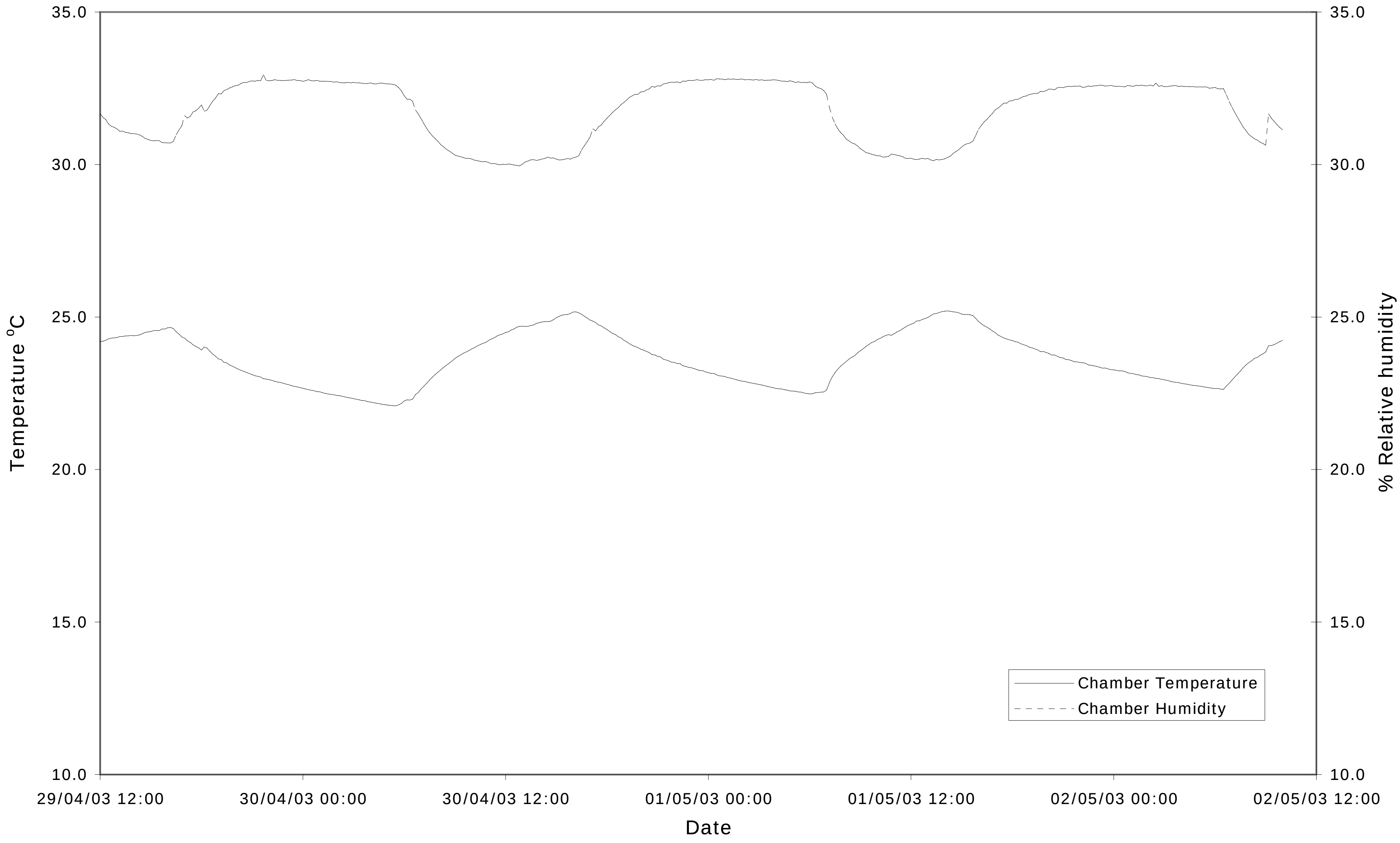


Figure 6 Temperature and relative humidity in the chamber during exposure 2

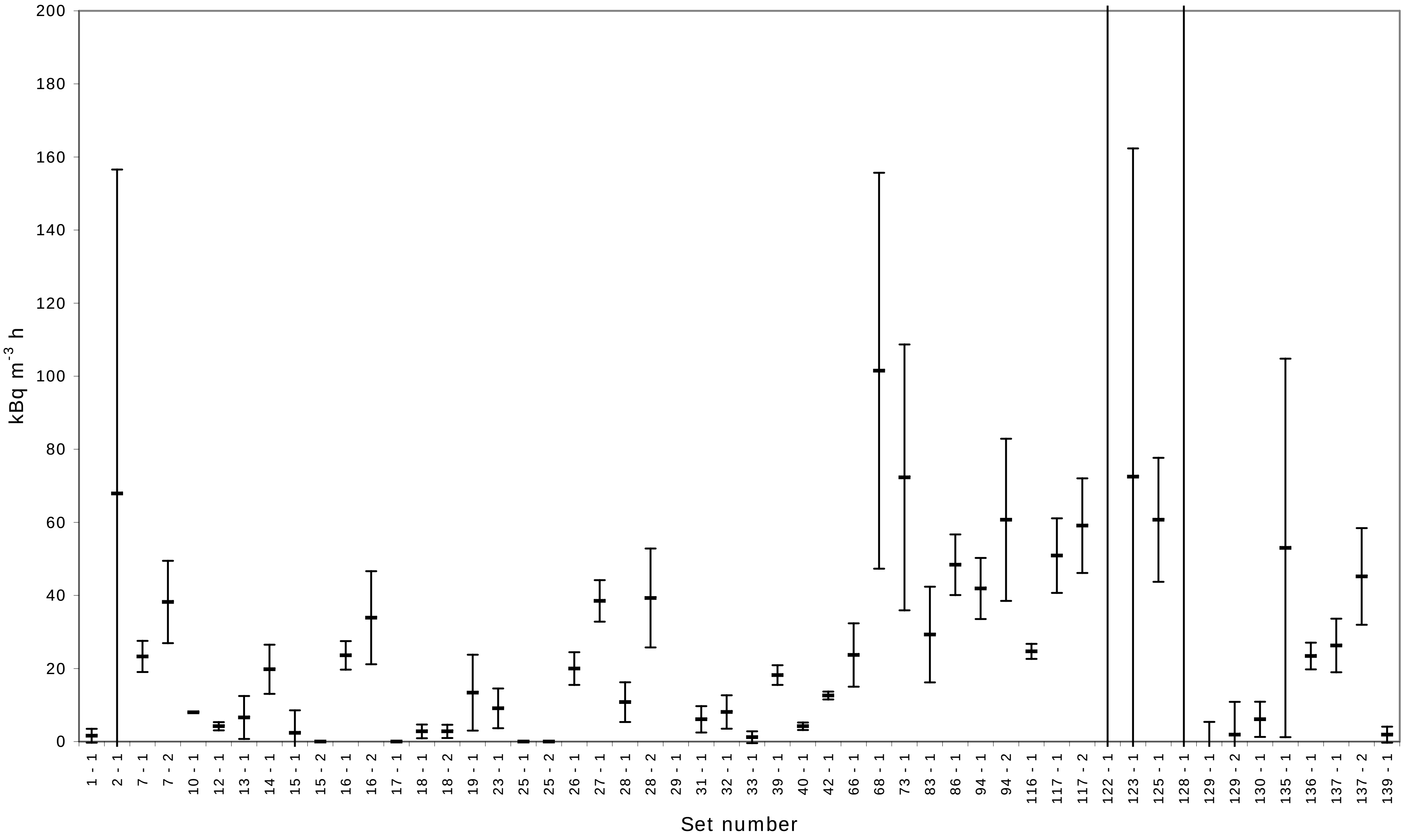


Figure 7 Results for transit detectors

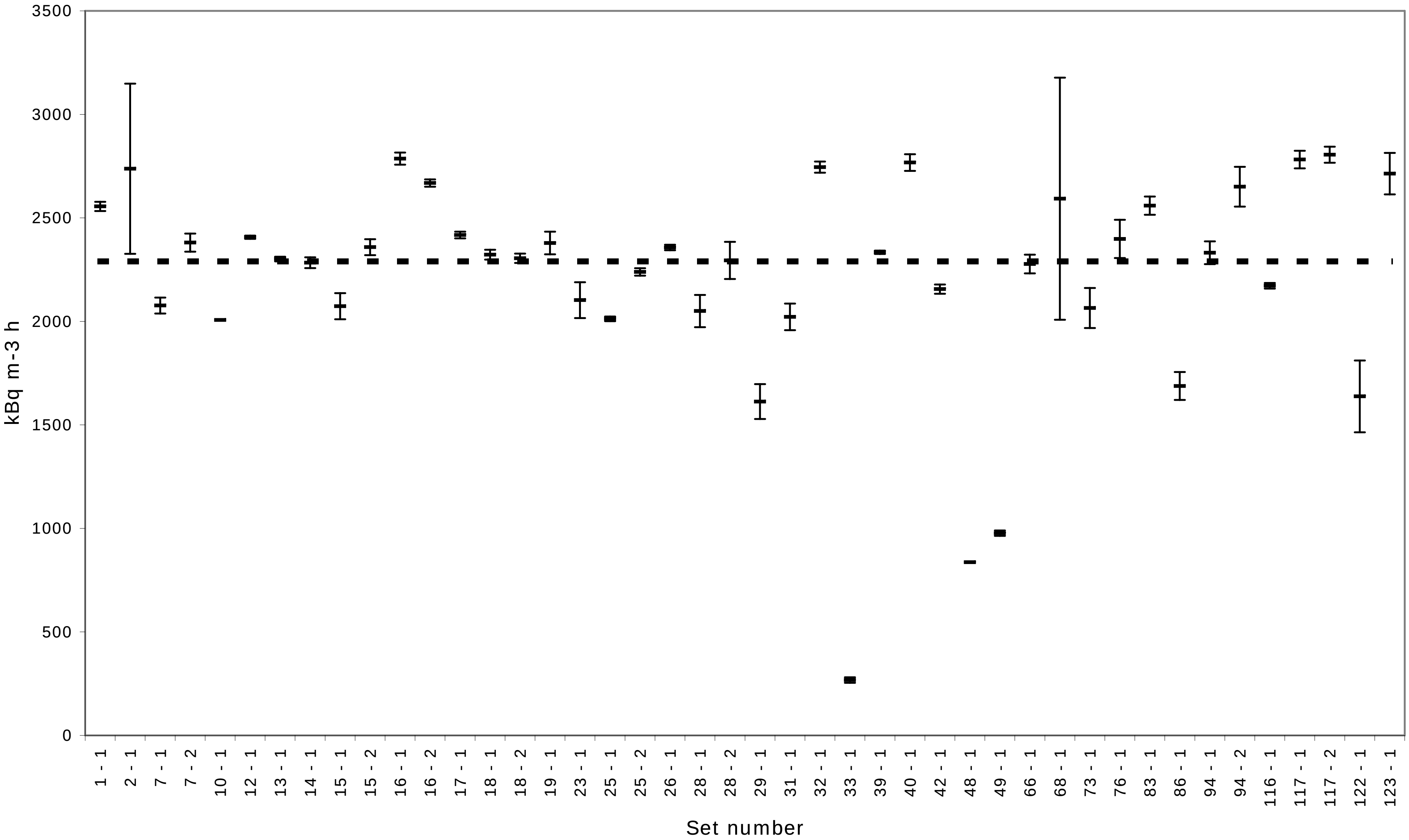


Figure 8 Detector results with standard error exposure 1

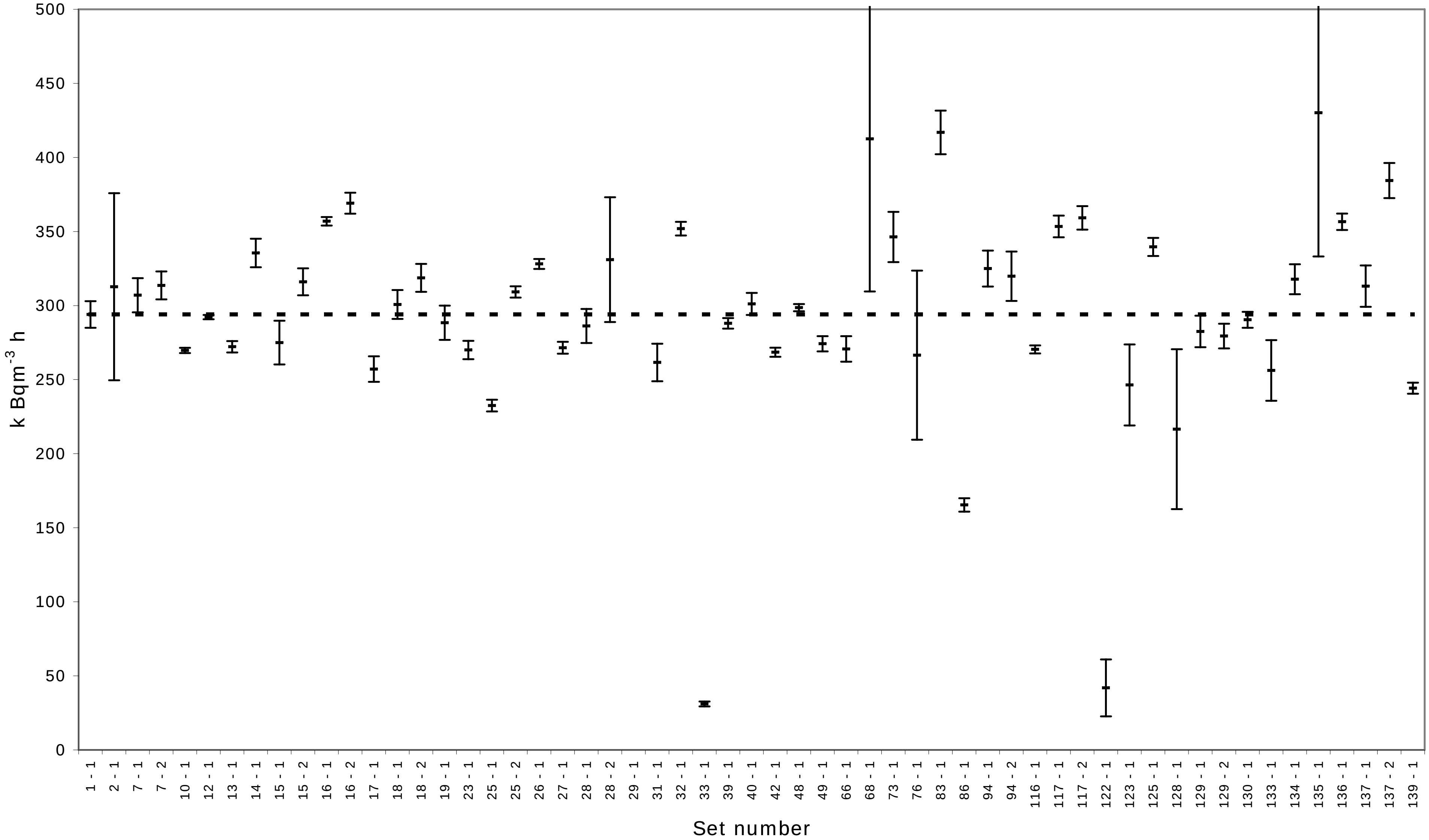


Figure 9 Detector results with standard error exposure 2

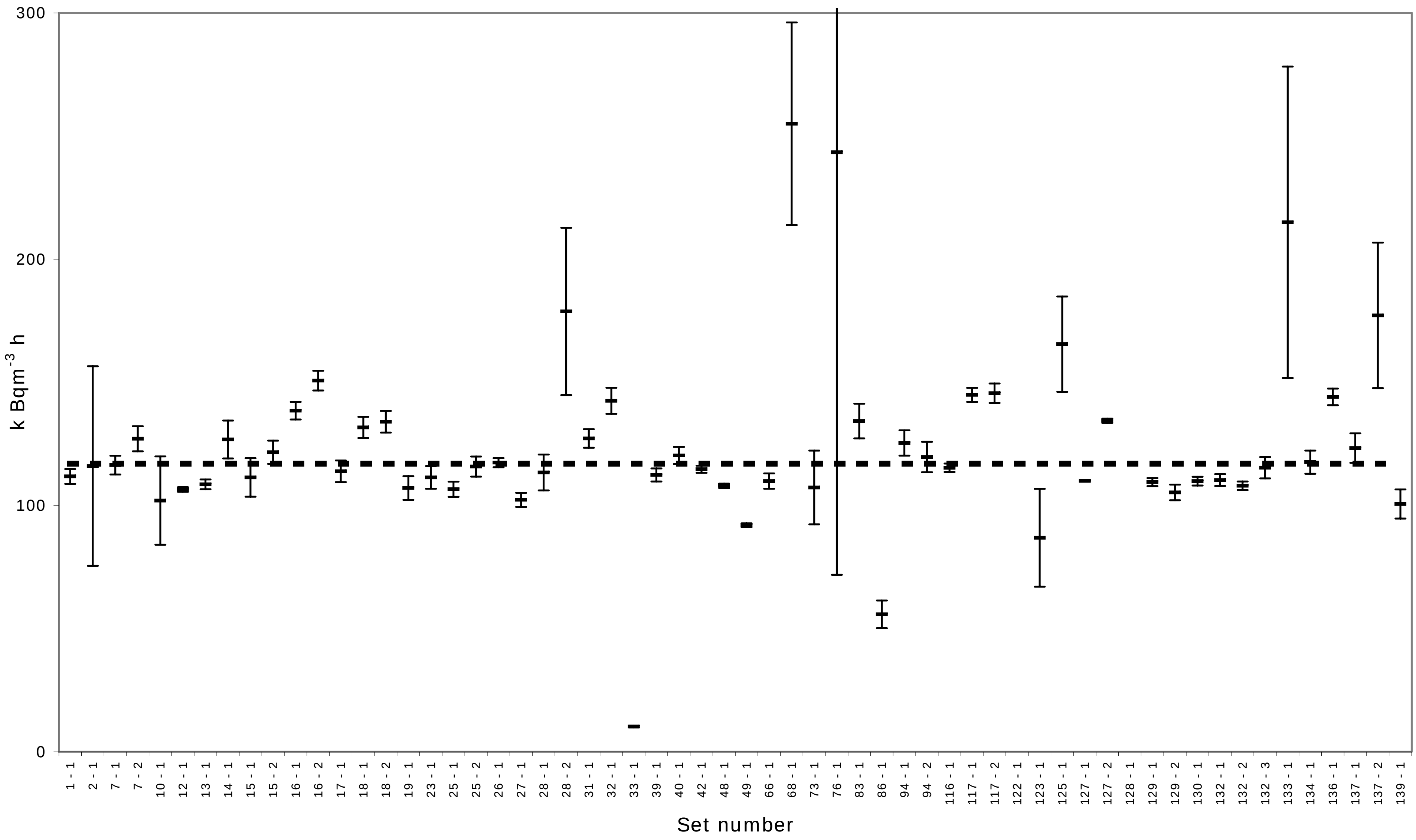


Figure 10 Detector results with standard error exposure 3

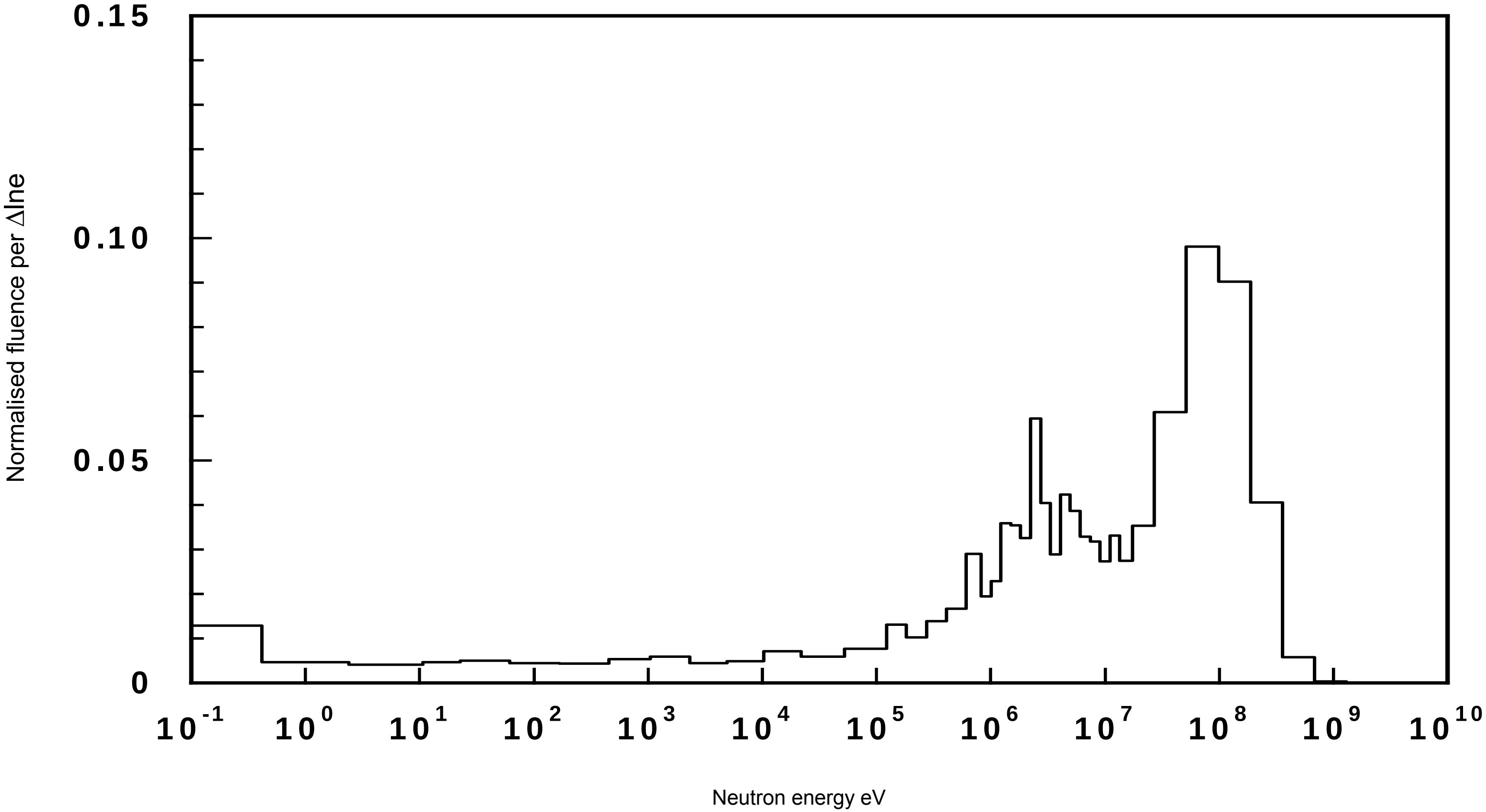


Figure 11. Calculated neutron energy spectrum above concrete shielding for 120 GeV/c +ve hadron beam (Rancati and Ferrari, 1996).

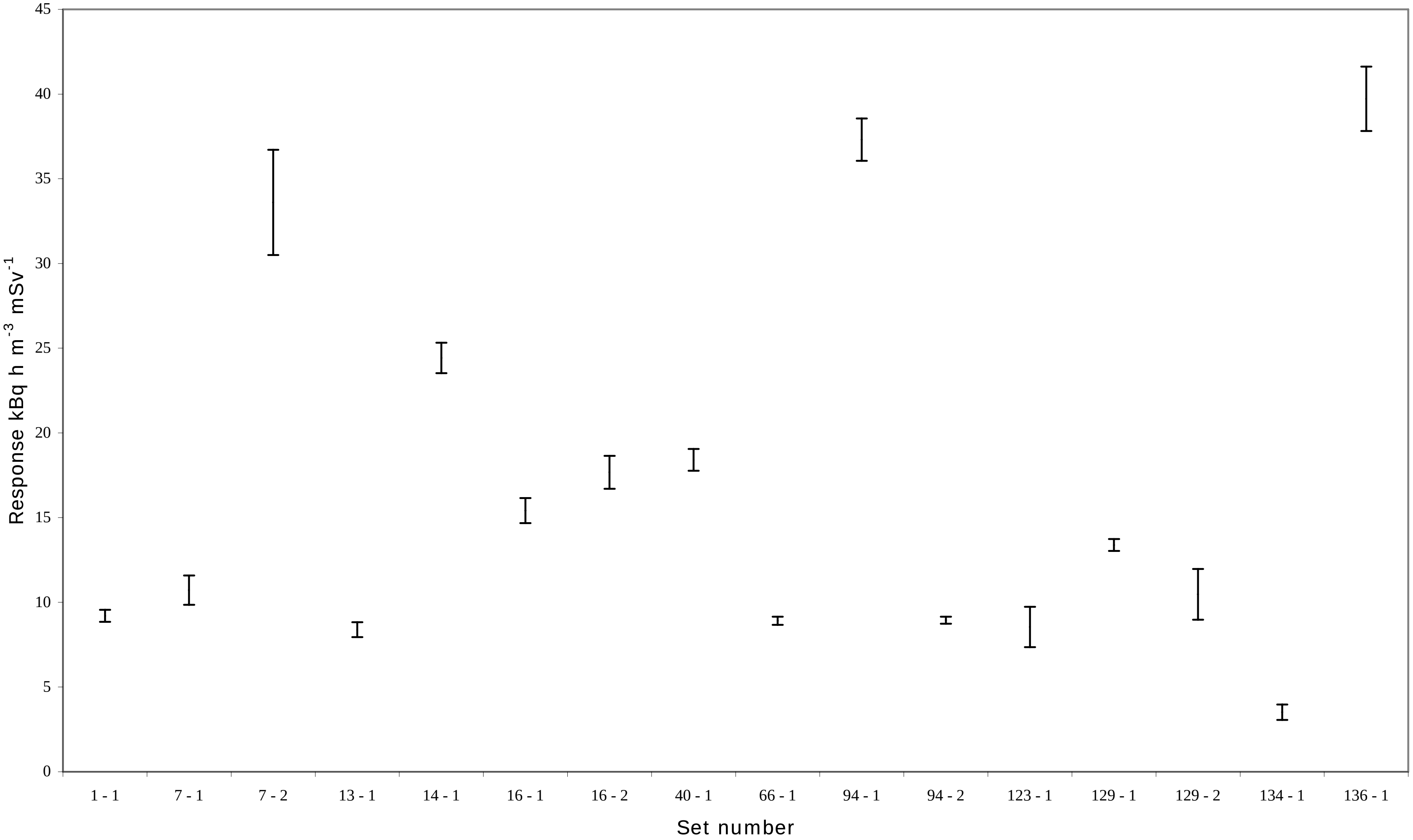


Figure 12 Response of detectors exposed at CERF showing maximum and minimum values

APPENDIX A

Characteristics of detectors used in the intercomparison

Laboratory
Nuclear Regulatory Authority
Av. Del Libertador 8250
1429 Capital Federal
Argentina

Scientists	Analia Canoba, Fabio Lopez
Contact	Analia Canoba
Telephone	+54 11 4379 8363
Fax	+54 11 43795 8460
Email	acanoba@cae.arn.gov.ar

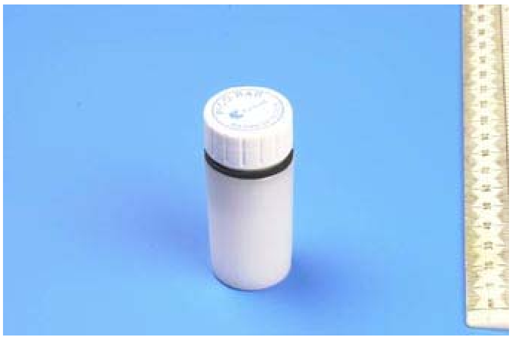
Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Detector characteristics	
Holder design	
Counting method	
Diffusion barrier in holder	Yes
Humidity correction applied	Yes

Calibration and exposure	
Calibration method	
Typical calibration exposure (kBq h m^{-3})	
Normal exposure duration (days)	1 - 4
Normal exposure range (kBq h m^{-3})	
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	

Reference:

Detector:



Laboratory:
Nuclear Regulatory Authority
Av. Del Libertador 8250
1429 Capital Federal
Argentina

Scientists	Analia Canoba, Fabio Lopez
Contact	Analia Canoba
Telephone	+54 11 43798363
Fax	+54 11 43798460
Email	acanoba@cae.arn.gov.ar

Calibration and exposure	
Calibration method:	
Typical calibration exposure (kBq h m^{-3})	
Normal exposure duration (days)	2-7
Normal exposure range (kBq h m^{-3})	
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	

Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Detector characteristics	
Holder design:	
Rad Elec E-Perm system?	Yes
Other:	
Holder (S/large, L/small):	
Gamma correction calculated:	Yes
Gamma correction measured:	No

Reference:

Detector:

Laboratory:
Dosirad
Villa Parc, Le Chêne
Rue Lech Walesa
F-77185 Lognes
France

Scientists:	Jean Andru
Contact:	Jean Andru
Telephone:	+33 1 60179213
Fax:	+33 1 60179196
Email:	dosirad@wanadoo.fr

Calibration and exposure:	
Calibration method:	Simulated radon source
Typical calibration exposure (kBq h m^{-3})	1000
Normal exposure duration (days)	7 - 365
Normal exposure range (kBq h m^{-3})	10 - 50000
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	~1.3 * statistical uncertainty

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Open
Holder design	Own
Holder antistatic measures	None
Detector antistatic measures	None

Detector characteristics:	
Detector material	LR115
Detector thickness (mm)	0.012 (active)
Detector size (mm^{-2})	220

Etching	Chemical/ pre-etch	Electro-chemical
Time (h)	1.5	
Solution	NaOH	
Strength (%)	10	
Temperature ^{o}C	60	
Chemical stirring?	No	
Field (kV cm^{-1})		
Frequency (kHz)		

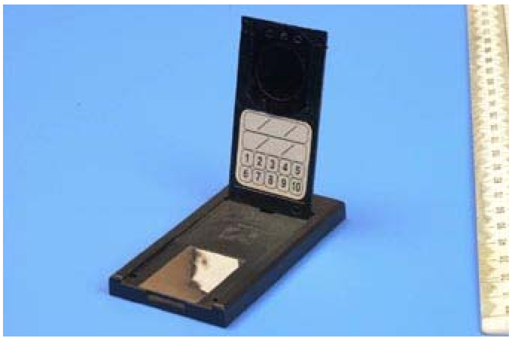
Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	1.8
Typical background (kBq h m^{-3})	2
SD on background (kBq h m^{-3})	2
Saturation (MBq h m^{-3})	60

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	100
Number of fields counted per detector:	1
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:

Detector:



Laboratory:
Dosirad
Villa Parc, Le Chêne
Rue Lech Walesa
F-77185 Lognes
France

Scientists:	Jean Andru
Contact:	Jean Andru
Telephone:	+33 1 60179213
Fax:	+33 1 60179196
Email:	dosirad@wanadoo.fr

Calibration and exposure:	
Calibration method:	Simulated radon source
Typical calibration exposure (kBq h m^{-3})	1000
Normal exposure duration (days)	10 - 365
Normal exposure range (kBq h m^{-3})	15 - 50000
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	~1.3 * statistical uncertainty

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Experimental

Characteristics:	
Holder type	Closed without filter
Holder design	Own
Holder antistatic measures	None
Detector antistatic measures	None

Detector characteristics:	
Detector material	LR115
Detector thickness (mm)	0.012 (active)
Detector size (mm^{-2})	220

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	1.5	
Solution	NaOH	
Strength (%)	10	
Temperature °C	60	
Chemical stirring?	No	
Field (kV cm^{-1})		
Frequency (kHz)		

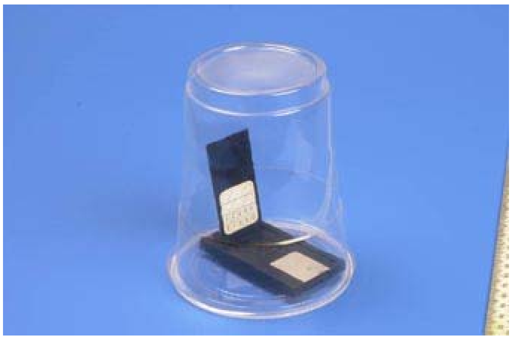
Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	1.2
Typical background (kBq h m^{-3})	2
SD on background (kBq h m^{-3})	2
Saturation (MBq h m^{-3})	70

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	100
Number of fields counted per detector:	1
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	
Constant current:	
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:

Detector:



Laboratory:
Bundesamt für Strahlenschutz
Köpernicker Allee 120 - 130
_10348 Berlin
Germany

Scientists:	Thomas Beck
Contact:	Thomas Beck
Telephone:	+49 1 88 333 4211
Fax:	+49 1 888 333 4215
Email:	tbeck@bfs.de

Calibration and exposure:	
Calibration method:	Calibration chamber
Typical calibration exposure (kBq h m^{-3})	50 - 10000
Normal exposure duration (days)	90 - 180
Normal exposure range (kBq h m^{-3})	50 - 10000
Quoted uncertainty in this range	<20%
Basis of uncertainty (eg 95% CL)	95%CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed with filter
Holder design	Own
Holder antistatic measures	Conducting holder
Detector antistatic measures	None

Detector characteristics:	
Detector material	Makrofol
Detector thickness (mm)	0.3
Detector size (mm^{-2})	50

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)		1.1 h/0.7h
Solution		KOH/EtOH
Strength (%)		40:60
Temperature ^{o}C		
Chemical stirring?	No	
Field (kV cm^{-1})		4
Frequency (kHz)		100 -3000

Detector performance:	
Sensitivity (tracks/cm^{2}/kBq h m^{-3})	1.6
Typical background (kBq h m^{-3})	0
SD on background (kBq h m^{-3})	6
Saturation (MBq h m^{-3})	20

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	Yes

Reference:

Detector:

Laboratory:
Karlsruhe Research Centre
Dosimetry service
PO Box 3640
D76021 Karlsruhe
Germany

Scientists:	S Ugi, E Kammerichs
Contact:	S Ugi
Telephone:	+49 7247 822644
Fax:	+49 7247 822 054
Email:	siegfried.ugi@hs.fzk.de

Calibration and exposure:	
Calibration method:	Exposure at three known concentrations
Typical calibration exposure (kBq h m^{-3})	120/350/1820
Normal exposure duration (days)	1 - 300
Normal exposure range (kBq h m^{-3})	20 - 2000
Quoted uncertainty in this range	<20%
Basis of uncertainty (eg 95% CL)	95%CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed with filter
Holder design	Kfk FN
Holder antistatic measures	Conducting folder
Detector antistatic measures	Aluminised film

Detector characteristics:	
Detector material	Makrofol
Detector thickness (mm)	0.3
Detector size (mm^{-2})	350

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	3h 45	1h 45
Solution	KOH	6.5N KOH
Strength (%)	6.5N	50
Temperature ^{o}C		
Chemical stirring?	No	
Field (kV cm^{-1})		35
Frequency (kHz)		3

Detector performance:	
Sensitivity (tracks/cm^{2}/kBq h m^{-3})	0.875
Typical background (kBq h m^{-3})	5
SD on background (kBq h m^{-3})	2
Saturation (MBq h m^{-3})	2

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:
DIN 25 706, 1993

Detector:

Laboratory:
Institute of Nuclear Research
Bem ter 18/c
Debrecen
H-4026
Hungary

Scientists:	Dr Istvan Csige
Contact:	Dr Istvan Csige
Telephone:	+36 52 417 266
Fax:	+36 52 416 181
Email:	csige@atomki.hu

Calibration and exposure:	
Calibration method:	
Typical calibration exposure ($kBq\ h\ m^{-3}$)	
Normal exposure duration (days)	30 - 365
Normal exposure range ($kBq\ h\ m^{-3}$)	10 - 10000
Quoted uncertainty in this range	25%
Basis of uncertainty (eg 95% CL)	95% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	Yes
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed with filter
Holder design	Own
Holder antistatic measures	Conducting holder
Detector antistatic measures	None

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	200

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	5	
Solution	NaOH	
Strength (%)	20	
Temperature ^{o}C	70	
Chemical stirring?	No	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

Detector performance:	
Sensitivity ($tracks/cm^{2}/kBq\ h\ m^{-3}$)	1.65
Typical background ($kBq\ h\ m^{-3}$)	10
SD on background ($kBq\ h\ m^{-3}$)	3
Saturation ($MBq\ h\ m^{-3}$)	1000

Track counting:	
Manual (M) or Automatic (A):	Manual
Area of one counting field (mm^{-2}):	0.25
Number of fields counted per detector:	4
OR minimum number of tracks counted:	1000
Autofocus:	No
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:
I Csige and S Csegzi. The Radamon radon detector and an example of application. Radiation Measurements, 34 (2001) 437 - 440.

Detector:

Laboratory:
Radon Laboratory Services
Carrick-on-Shannon Business Park
Carrick-on-Shannon
Co Leitrim
Ireland

Scientists:	J Higgins, D Higgins
Contact:	J Higgins
Telephone:	+353 07820724
Fax:	+353 07822873
Email:	info@rls.ie

Calibration and exposure:	
Calibration method:	E77 method
Typical calibration exposure (kBq h m^{-3})	
Normal exposure duration (days)	90 - 180
Normal exposure range (kBq h m^{-3})	40 - 8000
Quoted uncertainty in this range	15
Basis of uncertainty (eg 95% CL)	1 SD

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	RAD/E77
Holder antistatic measures	Antistatic dip
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	46.8

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	4	
Solution	NaOH	
Strength (%)	25	
Temperature °C	90	
Chemical stirring?	Yes	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	2.6
Typical background (kBq h m^{-3})	15
SD on background (kBq h m^{-3})	3
Saturation (MBq h m^{-3})	20

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:

Detector:

Laboratory:
RPII
3 Clonskeagh Square
Clonskeagh Road
Dublin 14
Ireland

Scientists:	J Madden, M O'Colmáin
Contact:	J Madden
Telephone:	+353 1 2697766
Fax:	+353 1 2697437
Email:	jmadden@rpii.ie

Calibration and exposure:	
Calibration method:	RPII radon chamber
Typical calibration exposure (kBq h m^{-3})	420
Normal exposure duration (days)	90 - 270
Normal exposure range (kBq h m^{-3})	30 - 7000
Quoted uncertainty in this range	15
Basis of uncertainty (eg 95% CL)	1SD

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	NRPB/SSI
Holder antistatic measures	Conducting holder
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	481

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	8	
Solution	NaOH	
Strength (%)	25	
Temperature °C	75	
Chemical stirring?	No	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	2.8
Typical background (kBq h m^{-3})	11
SD on background (kBq h m^{-3})	6
Saturation (MBq h m^{-3})	27

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	Yes
Constant current:	No
Constant light output:	No
Regular check of reference detector:	Yes

Reference:

Detector:

Laboratory
Environmental Services Company
Str. Yitzhak sade 40
POB 51631
Tel Aviv 67212
Israel

Scientists	Natan Lavi, Victor Steiner
Contact	Victor Steiner
Telephone	+972 3 5374850
Fax	+972 3 5374860
Email	esc@sviva.gov.il

Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	Yes
Routine/experimental?	Routine

Detector characteristics	
Holder design	
Counting method	Gamma spectrometry
Diffusion barrier in holder	Yes
Humidity correction applied	No

Calibration and exposure	
Calibration method	
Typical calibration exposure ($kBq\ h\ m^{-3}$)	
Normal exposure duration (days)	3 - 7
Normal exposure range ($kBq\ h\ m^{-3}$)	1.5 - 2000
Quoted uncertainty in this range	95% CL
Basis of uncertainty (eg 95% CL)	95% CL

Reference:

Detector:

Laboratory:
ARPA - Sez. Piacenza
Via XXI Aprile 48
Piacenza
Italy

Scientists	Laura Gaidolfi
Contact	Laura Gaidolfi
Telephone	+39 0523 489673
Fax	+39 0523 482480
Email	lgaidolfi@pc.arpa.emre.it

Calibration and exposure	
Calibration method:	
Typical calibration exposure (kBq h m^{-3})	
Normal exposure duration (days)	15 - 60
Normal exposure range (kBq h m^{-3})	15 - 300
Quoted uncertainty in this range	10%
Basis of uncertainty (eg 95% CL)	95%

Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Detector characteristics	
Holder design:	
Rad Elec E-Perm system?	Yes
Other:	
Holder (S/large, L/small):	
Gamma correction calculated:	No
Gamma correction measured:	Yes

Reference:

Detector:

Laboratory:
ARPA Lombardia - Dip. Milano
Via Juvara 22
20129 Milano
Italy

Scientists:	Dr Rosella Rusconi
Contact:	Dr Rosella Rusconi
Telephone:	+39 02 75722309
Fax:	+39 02 70184857
Email:	rosella.rusconi@email.it

Calibration and exposure:	
Calibration method:	NRPB
Typical calibration exposure (kBq h m^{-3})	110 - 2000
Normal exposure duration (days)	90 - 180
Normal exposure range (kBq h m^{-3})	90 - 1300
Quoted uncertainty in this range	10 - 40%
Basis of uncertainty (eg 95% CL)	68%CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	ANPA
Holder antistatic measures	
Detector antistatic measures	Aluminised film

Detector characteristics:	
Detector material	LR115
Detector thickness (mm)	
Detector size (mm^{-2})	

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	1h 10	
Solution	NaOH	
Strength (%)	10	
Temperature °C	60	
Chemical stirring?	No	
Field (kV cm^{-1})		
Frequency (kHz)		

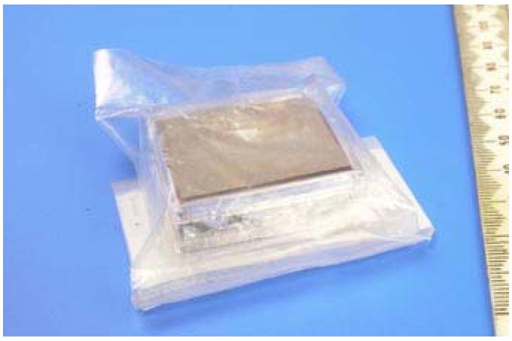
Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	0.47
Typical background (kBq h m^{-3})	40
SD on background (kBq h m^{-3})	5
Saturation (MBq h m^{-3})	

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:

Detector:



Laboratory:
ARPA Piemonte Dip. Ivrea
Via Jervis 30
10015 Ivrea (TO)
Italy

Scientists:	Mauro Magnoni, Franco Righino, Enrico Chiaberto
Contact:	Maro Magnoni
Telephone:	+39 0125 6453549
Fax:	+39 0125 6453584
Email:	m.magnoni@arpa.piemonte.it

Calibration and exposure:	
Calibration method:	
Typical calibration exposure ($kBq\ h\ m^{-3}$)	
Normal exposure duration (days)	60 - 180
Normal exposure range ($kBq\ h\ m^{-3}$)	70 - 2000
Quoted uncertainty in this range	10%
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	
Holder design	ANPA
Holder antistatic measures	
Detector antistatic measures	

Detector characteristics:	
Detector material	LR115
Detector thickness (mm)	
Detector size (mm^{-2})	

Etching	Chemical/ Pre-etch	Electro-chemical
Time (h)	1h 50	
Solution	NaOH	
Strength (%)	10%	
Temperature °C	60	
Chemical stirring?	No	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

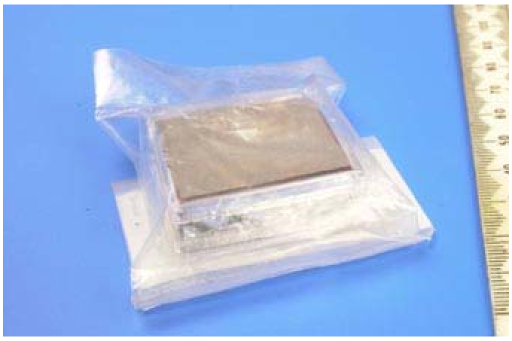
Detector performance:	
Sensitivity ($tracks/cm^2/kBq\ h\ m^{-3}$)	0.7486
Typical background ($kBq\ h\ m^{-3}$)	15
SD on background ($kBq\ h\ m^{-3}$)	
Saturation ($MBq\ h\ m^{-3}$)	3

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	100
Number of fields counted per detector:	2
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	Yes
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:

Detector:



Laboratory:
ARPAV - CRR - Dipartimento di Verona
Via Dominutti - Basso Acquar
37100 Verona
Italy

Scientists:	Dr Falvio Trotti
Contact:	@arpa.veneto.it
Telephone:	+39 45 8016907
Fax:	+39 45 8016777
Email:	ecaldognetto

Calibration and exposure:	
Calibration method:	NRPB radon chamber
Typical calibration exposure ($kBq\ h\ m^{-3}$)	1000
Normal exposure duration (days)	90 - 180
Normal exposure range ($kBq\ h\ m^{-3}$)	100 - 5000
Quoted uncertainty in this range	<20%
Basis of uncertainty (eg 95% CL)	95% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	no
Routine/experimental?	Both

Characteristics:	
Holder type	Closed without filter
Holder design	ANPA
Holder antistatic measures	
Detector antistatic measures	

Detector characteristics:	
Detector material	LR115
Detector thickness (mm)	
Detector size (mm^{-2})	

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)		
Solution		
Strength (%)		
Temperature °C		
Chemical stirring?	No	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

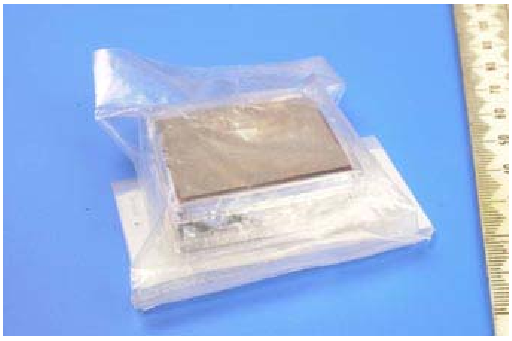
Detector performance:	
Sensitivity ($tracks/cm^2/kBq\ h\ m^{-3}$)	
Typical background ($kBq\ h\ m^{-3}$)	
SD on background ($kBq\ h\ m^{-3}$)	
Saturation ($MBq\ h\ m^{-3}$)	

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:

Detector:



Laboratory:
ARPAV - CRR-Dipartimento di Verona
Via Dominuti - Basso Acquar
37100 Verona
Italy

Scientists:	Dr Flavio Trotti
Contact:	Elena Caldognetto
Telephone:	+39 45 8016907
Fax:	+39 45 8016777
Email:	ecaldognetto@arpa.veneto.it

Calibration and exposure:	
Calibration method:	From supplier based on previous intercomparisons
Typical calibration exposure (kBq h m^{-3})	300
Normal exposure duration (days)	50 - 100
Normal exposure range (kBq h m^{-3})	100 - 5000
Quoted uncertainty in this range	<20%
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Both

Characteristics:	
Holder type	Closed withour filter
Holder design	RAD/E77
Holder antistatic measures	Antistatic dip
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	100

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	4	
Solution	NaOH	
Strength (%)	20%	
Temperature ^{o}C	90	
Chemical stirring?	Yes	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	2.9
Typical background (kBq h m^{-3})	19
SD on background (kBq h m^{-3})	8
Saturation (MBq h m^{-3})	6.5

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	0.35
Number of fields counted per detector:	144
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:
Radosys 2000 system produced by 77 Elektronika KFT (Hungary)

Detector:

Laboratory:
ARPAV Dip of Padova
via Ospedale 22
35100 Padova
Italy

Scientists	Dr Andrea Bertolo
Contact	Dr Andrea Bertolo
Telephone	+39 498227874
Fax	+39498227810
Email	abertolo@arpa.veneto.it

Calibration and exposure	
Calibration method:	
Typical calibration exposure (kBq h m^{-3})	
Normal exposure duration (days)	90 - 365
Normal exposure range (kBq h m^{-3})	200 - 8000
Quoted uncertainty in this range	25
Basis of uncertainty (eg 95% CL)	95%CL

Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Detector characteristics	
Holder design:	
Rad Elec E-Perm system?	Yes
Other:	
Holder (S/large, L/small):	
Gamma correction calculated:	Yes
Gamma correction measured:	No

Reference:

Detector:

Laboratory:
Gaia Consulting and Technologies
Via Gorizia 35/37
20099 Sesto San Giovanni
Milano
Italy

Scientists	Simona Rullo, Riccardo Florio
Contact	Simona Rullo
Telephone	+39 02 24416972
Fax	+39 02 24304434
Email	rullo@gaiaconsulting.info

Calibration and exposure	
Calibration method:	
Typical calibration exposure (kBq h m^{-3})	
Normal exposure duration (days)	30 - 90
Normal exposure range (kBq h m^{-3})	
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	95% CL

Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Detector characteristics	
Holder design:	
Rad Elec E-Perm system?	Yes
Other:	
Holder (S/large, L/small):	
Gamma correction calculated:	Yes
Gamma correction measured:	No

Reference:
Rad Elec Inc specifications

Detector:

Laboratory:
Lab. Chimica Fisica
Agenzia Provinciale Protezione Ambiente
Via Amba Alagi, 5
I-39100 Bolzano
Italy

Scientists:	Dr Luca Verdi
Contact:	Dr Luca Verdi
Telephone:	+39 0471 29102
Fax:	+39 0471 283264
Email:	luca.verdi@provincia.bz.it

Calibration and exposure:	
Calibration method:	By supplier based on previous intercomparison
Typical calibration exposure (kBq h m^{-3})	300
Normal exposure duration (days)	2 - 200
Normal exposure range (kBq h m^{-3})	20 - 6000
Quoted uncertainty in this range	20
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Experimental

Characteristics:	
Holder type	Closed without filter
Holder design	RAD
Holder antistatic measures	Antistatic dip
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR 39
Detector thickness (mm)	1
Detector size (mm^{-2})	100

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	4	
Solution	NaOH	
Strength (%)	20	
Temperature °C	90	
Chemical stirring?	Yes	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	
Typical background (kBq h m^{-3})	
SD on background (kBq h m^{-3})	
Saturation (MBq h m^{-3})	

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	0.35
Number of fields counted per detector:	144
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:

Detector:

Laboratory:
Lab. Chimica Fisica
Agenzia Provinciale Protezione Ambiente
Via Amba Alagi, 5
I-39100 Bolzano
Italy

Scientists:	Dr Luca Verdi
Contact:	Dr Luca Verdi
Telephone:	+39 0471 29102
Fax:	+39 0471 283264
Email:	luca.verdi@provincia.bz.it

Calibration and exposure:	
Calibration method:	Radon chamber with certified exposure
Typical calibration exposure (kBq h m^{-3})	200 - 1000
Normal exposure duration (days)	2 - 200
Normal exposure range (kBq h m^{-3})	20 - 6000
Quoted uncertainty in this range	30
Basis of uncertainty (eg 95% CL)	68% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	Yes
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed
Holder design	ANPA
Holder antistatic measures	None
Detector antistatic measures	Aluminised film

Detector characteristics:	
Detector material	LR-115
Detector thickness (mm)	0.012
Detector size (mm^{-2})	25x34

Etching	Chemical/ pre-etch	Electro-chemical
Time (h)	1h 50	
Solution	NaOH	
Strength (%)	10	
Temperature °C	60	
Chemical stirring?	No	
Field (kV cm^{-1})		
Frequency (kHz)		

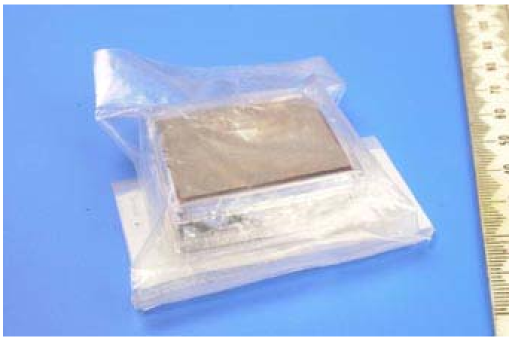
Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	0.9
Typical background (kBq h m^{-3})	11
SD on background (kBq h m^{-3})	2
Saturation (MBq h m^{-3})	7 - 8

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	100
Number of fields counted per detector:	1 - 2
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:
F. Bochicchio et al., Rad. Prot. Dos. 45 (1992) 459

Detector:



Laboratory:
Laboratorio Radioattivita
Via Vivaldi 43
81100 Caserta
Italy

Scientists:	C Sabbarese
Contact:	C Sabbarese
Telephone:	+39 823 274633
Fax:	+39 823 274605
Email:	carlo.sabbarese@unina2.it

Calibration and exposure:	
Calibration method:	
Typical calibration exposure ($kBq\ h\ m^{-3}$)	
Normal exposure duration (days)	30 - 180
Normal exposure range ($kBq\ h\ m^{-3}$)	<1200
Quoted uncertainty in this range	8%
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	ANPA
Holder antistatic measures	
Detector antistatic measures	None

Detector characteristics:	
Detector material	LR115
Detector thickness (mm)	0.012
Detector size (mm^{-2})	100

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	2	
Solution	NaOH	
Strength (%)		
Temperature °C	60	
Chemical stirring?	No	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

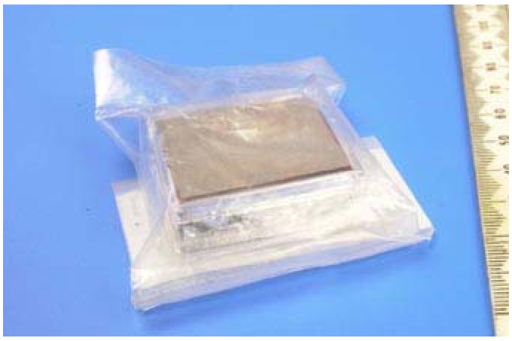
Detector performance:	
Sensitivity ($tracks/cm^{2}/kBq\ h\ m^{-3}$)	
Typical background ($kBq\ h\ m^{-3}$)	
SD on background ($kBq\ h\ m^{-3}$)	
Saturation ($MBq\ h\ m^{-3}$)	

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:

Detector:



Laboratory:
MCF snc
Via Beorchia 16
Pasian di Prato
33037 Udine
Italy

Scientists:	Stefano Colonnello, Silvia Pividore
Contact:	Stefano Colonnello
Telephone:	+39 0432 644018
Fax:	+39 0432 644091
Email:	info@mcfambiente.it

Calibration and exposure:	
Calibration method:	From supplier based on previous intercomparison
Typical calibration exposure (kBq h m^{-3})	300
Normal exposure duration (days)	60 - 120
Normal exposure range (kBq h m^{-3})	100 - 5000
Quoted uncertainty in this range	20%
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Both

Characteristics:	
Holder type	Closed
Holder design	Radosys
Holder antistatic measures	Antistatic dip
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	100

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	4	
Solution	NaOH	
Strength (%)	25	
Temperature ^{o}C	90	
Chemical stirring?	Yes	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^{2}/kBq h m^{-3})	2.9
Typical background (kBq h m^{-3})	19
SD on background (kBq h m^{-3})	8
Saturation (MBq h m^{-3})	6.5

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	yes

Reference:

Detector:

Laboratory:
RINI- Settore Radon
ISPESL -via Fontana Candida
N.1 - 00040
Monteforzio Catone (RM)
Italy

Scientists:	Rosabianca Trevisi
Contact:	Rosabianca Trevisi
Telephone:	+39 06 94181434
Fax:	+39 06 9419453
Email:	r.trevisi@dil.ispesl.it

Calibration and exposure:	
Calibration method:	
Typical calibration exposure (kBq h m^{-3})	700
Normal exposure duration (days)	
Normal exposure range (kBq h m^{-3})	
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	yes
Routine/experimental?	

Characteristics:	
Holder type	
Holder design	NRPB/SSI
Holder antistatic measures	Conducting holder
Detector antistatic measures	

Detector characteristics:	
Detector material	
Detector thickness (mm)	1
Detector size (mm^{-2})	455

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	5.5	
Solution	KOH	
Strength (%)	30%	
Temperature °C	80	
Chemical stirring?	Yes	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	2.8
Typical background (kBq h m^{-3})	14
SD on background (kBq h m^{-3})	5.0
Saturation (MBq h m^{-3})	

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	Yes

Reference:

Detector:

Laboratory:
Radon Research group
National Institute of Radiological Sciences
4-9-1 Anagawa, Inage-ku
Chiba 263-8555
Japan

Scientists:	Shinji Tokonami
Contact:	Shinji Tokonanmi
Telephone:	+81 43 206 3105
Fax:	+81 43 206 4098
Email:	Tokonami@nirs.go.jp

Calibration and exposure:	
Calibration method:	Radon chamber
Typical calibration exposure ($kBq\ h\ m^{-3}$)	360
Normal exposure duration (days)	3 - 5
Normal exposure range ($kBq\ h\ m^{-3}$)	200 - 600
Quoted uncertainty in this range	10%
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	RAD/E77
Holder antistatic measures	Conducting holder
Detector antistatic measures	

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	100

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	6h	
Solution	NaOH	
Strength (%)	25%	
Temperature ^oC	90	
Chemical stirring?	Yes	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

Detector performance:	
Sensitivity ($tracks/cm^2/kBq\ h\ m^{-3}$)	2.6
Typical background ($kBq\ h\ m^{-3}$)	40
SD on background ($kBq\ h\ m^{-3}$)	10
Saturation ($MBq\ h\ m^{-3}$)	4

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	yes

Reference:

Detector:

Laboratory:
Radiation Protection Centre
Kalvariju 153
LT-2042 Vilnius
Lithuania

Scientists	Gendrutis Morkunas
Contact	
Telephone	
Fax	
Email	genmo@takas.lt

Calibration and exposure	
Calibration method:	
Typical calibration exposure ($kBq\ h\ m^{-3}$)	
Normal exposure duration (days)	21 - 30
Normal exposure range ($kBq\ h\ m^{-3}$)	
Quoted uncertainty in this range	~10%
Basis of uncertainty (eg 95% CL)	

Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Both

Detector characteristics	
Holder design:	
Rad Elec E-Perm system?	Yes
Other:	
Holder (S/large, L/small):	
Gamma correction calculated:	Yes
Gamma correction measured:	No

Reference:

Detector:

Laboratory:
National Institute of Technology
Akersvn 24c
POB 2608 St. Hanshaugen
0131 Oslo
Norway

Scientists:	Aleksandar Birovljev
Contact:	Aleksandar Birovljev
Telephone:	+47 982 90235
Fax:	+47 223 61829
Email:	bira@teknologisk.no

Calibration and exposure:	
Calibration method:	Exposure at accredited lab
Typical calibration exposure (kBq h m^{-3})	200,400,800,1600
Normal exposure duration (days)	60 - 90
Normal exposure range (kBq h m^{-3})	50 - 2000
Quoted uncertainty in this range	8 - 18%
Basis of uncertainty (eg 95% CL)	95% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	Radosys
Holder antistatic measures	Conducting holder
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	100

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	4h	
Solution	NaOH	
Strength (%)	20	
Temperature ^{o}C	90	
Chemical stirring?	Yes	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	
Typical background (kBq h m^{-3})	
SD on background (kBq h m^{-3})	
Saturation (MBq h m^{-3})	

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	No

Reference:

Detector:

Laboratory:
Radonlab
POB 4780 Sofienberg
0506 Oslo
Norway

Scientists:	Tor Bertheusen
Contact:	Tor Bertheusen
Telephone:	+47 95129366
Fax:	+47 90433880
Email:	post@radonlab.net

Calibration and exposure:	
Calibration method:	Exposure in chamber
Typical calibration exposure (kBq h m^{-3})	500
Normal exposure duration (days)	60 - 120
Normal exposure range (kBq h m^{-3})	150 - 2500
Quoted uncertainty in this range	7 - 11%
Basis of uncertainty (eg 95% CL)	95% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	RAD/E77
Holder antistatic measures	Antistatic dip/conducting holder
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	100

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	4	
Solution	NaOH	
Strength (%)	20	
Temperature °C	90	
Chemical stirring?	Yes	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	
Typical background (kBq h m^{-3})	
SD on background (kBq h m^{-3})	
Saturation (MBq h m^{-3})	

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	Yes

Reference:
Closed without filter

Detector:

Laboratory:
Rødmyr Miljøsenter
Postboks 5202
3702 Skein
Norway

Scientists:	Bente Fjerdingen
Contact:	Bente Fjerdingen
Telephone:	+35 50 56 00
Fax:	+35 50 56 20
Email:	sigrun.nordeide.johansen@rodmyr .miljosenter.no

Calibration and exposure:	
Calibration method:	Check of reference detector
Typical calibration exposure (kBq h m^{-3})	500
Normal exposure duration (days)	60 - 90
Normal exposure range (kBq h m^{-3})	100 - 1000
Quoted uncertainty in this range	<20%
Basis of uncertainty (eg 95% CL)	95% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	No
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	NRPB/SSI
Holder antistatic measures	Conducting holder
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	430

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	17	
Solution	NaOH	
Strength (%)	25	
Temperature °C	70	
Chemical stirring?	no	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	2.0
Typical background (kBq h m^{-3})	20
SD on background (kBq h m^{-3})	
Saturation (MBq h m^{-3})	

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	Yes

Reference:
B Majborn, 1986. T Strand, SIS, 1989:5

Detector:

Laboratory:
Institute of Occupational Medicine
8 SW tersy Str.
90-950 Lodz
PO Box 199
Poland

Scientists:	D Kluszczynski, Z Kaminski
Contact:	D Kluszczynski
Telephone:	+48 42 6314 552
Fax:	+48 42 6314 548
Email:	klud@imp.lodz.pl

Calibration and exposure:	
Calibration method:	Radon chamber
Typical calibration exposure ($kBq\ h\ m^{-3}$)	1500
Normal exposure duration (days)	14 - 90
Normal exposure range ($kBq\ h\ m^{-3}$)	35 - 10000
Quoted uncertainty in this range	± 30%
Basis of uncertainty (eg 95% CL)	95% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Open
Holder design	Own
Holder antistatic measures	Antistatic dip.
Detector antistatic measures	

Detector characteristics:	
Detector material	LR115
Detector thickness (mm)	0.1
Detector size (mm^{-2})	20 x 30

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	2.3	
Solution	NaOH	
Strength (%)	9	
Temperature ^{o}C	55	
Chemical stirring?	No	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

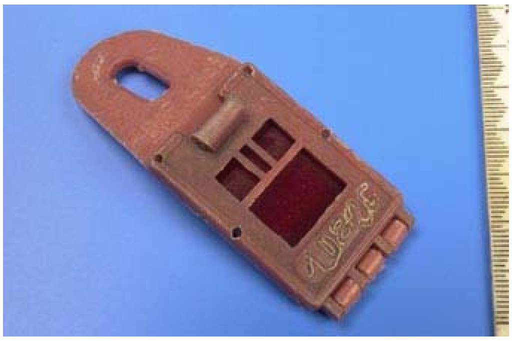
Detector performance:	
Sensitivity ($tracks/cm^2/kBq\ h\ m^{-3}$)	1.5
Typical background ($kBq\ h\ m^{-3}$)	5.1
SD on background ($kBq\ h\ m^{-3}$)	3.0
Saturation ($MBq\ h\ m^{-3}$)	~10

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	160
Number of fields counted per detector:	165
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:
Zorawski a, Czerski b., Method of calibaration and analysis of track detectors. Radiation Protection Practise, Vol. 1, pp 398 - 399.

Detector:



Laboratory:
Institute of Occupational Medicine
8 Sw Teresy Str.
PO Box 199
90-950 Lodz
Poland

Scientists:	D Kluszczynski, Z Kaminski
Contact:	D Kluszczynski
Telephone:	+48 42 6314552
Fax:	+48 42 6314 548
Email:	klud@imp.lodz.pl

Calibration and exposure:	
Calibration method:	Radon chamber
Typical calibration exposure ($kBq\ h\ m^{-3}$)	350
Normal exposure duration (days)	14 - 90
Normal exposure range ($kBq\ h\ m^{-3}$)	20 - 10000
Quoted uncertainty in this range	<20%
Basis of uncertainty (eg 95% CL)	95% CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	
Holder design	
Holder antistatic measures	
Detector antistatic measures	

Detector characteristics:	
Detector material	
Detector thickness (mm)	
Detector size (mm^{-2})	

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)		
Solution		
Strength (%)		
Temperature ^{o}C		
Chemical stirring?	No	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

Detector performance:	
Sensitivity ($tracks/cm^2/kBq\ h\ m^{-3}$)	
Typical background ($kBq\ h\ m^{-3}$)	
SD on background ($kBq\ h\ m^{-3}$)	
Saturation ($MBq\ h\ m^{-3}$)	

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:

Detector:

Laboratory
ZVD d.d.
Bohoriceva 22A
1000 Ljubljana
Slovenia

Scientists	Peter Jovanovic
Contact	Peter Jovanovic
Telephone	+386 1 4320253
Fax	+386 1 2312562
Email	peter.jovanic@zvd.si

Detector application	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	Yes
Routine/experimental?	Routine

Detector characteristics	
Holder design	Canister
Counting method	Gamma spectrometry
Diffusion barrier in holder	Yes
Humidity correction applied	Yes

Calibration and exposure	
Calibration method	
Typical calibration exposure (kBq h m^{-3})	
Normal exposure duration (days)	1 - 4
Normal exposure range (kBq h m^{-3})	10 - 15000
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	

Reference:

Detector:

Laboratory:
Dept. of Radiation Physics
Su/Sahlgrenska
SE 41345 Goteborg
Sweden

Scientists:	Raine Vesanen, Mats Isaksson
Contact:	Mats Isaksson
Telephone:	+46 31 3423849
Fax:	+46 31 822493
Email:	mats.isaksson@radfys.gu.se

Calibration and exposure:	
Calibration method:	SSI radon chamber
Typical calibration exposure (kBq h m^{-3})	700
Normal exposure duration (days)	30 - 90
Normal exposure range (kBq h m^{-3})	0 - 1000
Quoted uncertainty in this range	±25%
Basis of uncertainty (eg 95% CL)	1SD

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	No
Used for mines/caves?	No
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Experimental

Characteristics:	
Holder type	closed without filter
Holder design	NRPB/SSI
Holder antistatic measures	Conducting holder
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	
Detector size (mm^{-2})	

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	1	
Solution	NaOH	
Strength (%)	25%	
Temperature °C	98	
Chemical stirring?	No	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	
Typical background (kBq h m^{-3})	
SD on background (kBq h m^{-3})	
Saturation (MBq h m^{-3})	

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	No

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	No

Reference:

Detector:

Laboratory:
DSTL Radiation Protection Services
Institute of Naval Medicine
Crescent Rd., Alverstoke
Hants, PO12 2DL
United Kingdom

Scientists:	Roger Stokes, Laurence Jones
Contact:	Roger Stokes
Telephone:	+44 (0) 23 92 768294
Fax:	+44 (0) 23 92 768150
Email:	rpstokes@dstl.gov.uk

Calibration and exposure:	
Calibration method:	NRPB radon chamber
Typical calibration exposure ($kBq\ h\ m^{-3}$)	500
Normal exposure duration (days)	30 - 100
Normal exposure range ($kBq\ h\ m^{-3}$)	20 - 2000
Quoted uncertainty in this range	±20%
Basis of uncertainty (eg 95% CL)	95%CL

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	No
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	NRPB/SSI
Holder antistatic measures	Conducting holder
Detector antistatic measures	None

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1.5
Detector size (mm^{-2})	500

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	6	
Solution	NaOH	
Strength (%)	25	
Temperature ^oC	70	
Chemical stirring?	Yes	
Field ($kV\ cm^{-1}$)		
Frequency (kHz)		

Detector performance:	
Sensitivity ($tracks/cm^2/kBq\ h\ m^{-3}$)	2.0
Typical background ($kBq\ h\ m^{-3}$)	10.0
SD on background ($kBq\ h\ m^{-3}$)	2.5
Saturation ($MBq\ h\ m^{-3}$)	>5

Track counting:	
Manual (M) or Automatic (A):	
Area of one counting field (mm^{-2}):	
Number of fields counted per detector:	
OR minimum number of tracks counted:	
Autofocus:	Yes
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	Yes
Constant current:	Yes
Constant light output:	Yes
Regular check of reference detector:	Yes

Reference:
Internal DRPS report 13/95: DRPS CR39 radon detector environmental trial.

Detector:

Laboratory:
NRPB
Chilton
Didcot, Oxon
OX11 0RQ
United Kingdom

Scientists:	J Miles, Z - F Ibrahimi
Contact:	Jon Miles
Telephone:	+44 1235 831600
Fax:	+44 1235 833861
Email:	jon.miles@nrpb.org

Calibration and exposure:	
Calibration method:	Exposure in radon chamber
Typical calibration exposure (kBq h m^{-3})	400 - 500
Normal exposure duration (days)	30 - 365
Normal exposure range (kBq h m^{-3})	
Quoted uncertainty in this range	
Basis of uncertainty (eg 95% CL)	

Detector application:	
Used for dwellings?	Yes
Used for workplaces?	Yes
Used for mines/caves?	Yes
Used for outdoor?	Yes
Used for soil?	No
Routine/experimental?	Routine

Characteristics:	
Holder type	Closed without filter
Holder design	NRPB
Holder antistatic measures	Antistatic dip
Detector antistatic measures	Antistatic dip

Detector characteristics:	
Detector material	CR39
Detector thickness (mm)	1
Detector size (mm^{-2})	

Etching	**Chemical/ pre-etch**	**Electro-chemical**
Time (h)	18	
Solution	NaOH	
Strength (%)	20	
Temperature °C	81	
Chemical stirring?	No	
Field (kV cm^{-1})		
Frequency (kHz)		

Detector performance:	
Sensitivity (tracks/cm^2/kBq h m^{-3})	2.6
Typical background (kBq h m^{-3})	15
SD on background (kBq h m^{-3})	4
Saturation (MBq h m^{-3})	6

Track counting:	
Manual (M) or Automatic (A):	Automatic
Area of one counting field (mm^{-2}):	300
Number of fields counted per detector:	1
OR minimum number of tracks counted:	
Autofocus:	No
Correction for non-linearity:	Yes

Light level stabilisation for automatic counters:	
Constant voltage:	No
Constant current:	No
Constant light output:	No
Regular check of reference detector:	Yes

Reference:

Detector: