CAIRS-ALGADE PERSONAL ALPHA DOSIMETER

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INTRODUCTION

The CAIRS-ALGADE Personal Alpha Dosimeter (PAD) is a portable, lightweight personal monitoring system designed to measure individual exposures to radon and thoron progeny and Long-Lived Radioactive Dust (LLRD).

The CAIRS-ALGADE Personal Alpha Dosimeter consists of a CAIRS track etch detectors (dosimeter head) mounted in an ALGADE individual air sampling system designed to be worn on the belt of the individual to be monitored.

The PAD is worn by the individual for a period of one month. At the end of the month, the CAIRS dosimeter head is removed from the PAD and returned to the CAIRS National Laboratories in Saskatoon, Saskatchewan to be processed. Exposure results are supplied to the respective clients on a monthly basis. We will briefly discuss the CAIRS-ALGADE Personal Alpha Dosimeter, its operation and its capabilities for measuring radon and thoron progeny and LLRD.

ALGADE INDIVIDUAL SAMPLER AND CHARGER

The ALGADE individual sampler is an air pumping system designed to draw air through the CAIRS track etch detector (dosimeter head). A battery operated, centrifuge pump is enclosed in a durable polycarbonate box designed to be worn on the belt of the individual who is to be monitored.

The individual sampler is powered by a small rechargeable battery which, when fully charged, will operate properly for periods in excess of 10 hours. The sampler requires charging times of approximately 14 hours. The ALGADE individual sampler is designed to generate a nominal air flow rate at 4 l/h.

The following is a list of the technical specifications of the ALGADE Individual Sampler.

- A moulded polycarbonate box which houses the system;
- A centrifuge pump driven by a dc motor;
- An electronic module embodying:
  - a nickel-cadmium rechargeable battery, 1.2 V; 1.2 Ah;
  - a constant current charger;
  - a switch controlling the motor operation;
  - a light emitting diode illuminated when the battery is charging;
  - a magnet controlling the start-up of the charger;
- Operating time: in excess of 10 hours;
- Battery charging time: 14 hours;

  Dimensions: 94 x 79 x 63 cm;
- Weight: 230 g (excluding measuring head);
- Relative humidity: 0 to 100%
- Operating temperature: -10°C to 45 °C.

The ALGADE individual samplers are recharged using an ALGADE charging unit. The individual charging unit consists of a polycarbonate box forming a cell into which the individual sampler is placed. The charger includes an electronic card which generates a high frequency alternating current which feeds a coil. This coil supplies by induction the energy necessary to recharge the battery in the individual sampler. It also includes a magnetically operated switch which gates the power

supply to the electronic card when the sampler is placed in the cell and controls an hour-meter which makes it possible to measure the operating time of the sampler.

CAIRS DOSIMETER HEAD

The CAIRS Dosimeter Head is designed and manufactured in Canada. The dosimeter head is an adaptation of an integrated measuring head originally developed by the Atomic Energy Commission of France (CEA). The dosimeter head is designed to detect the presence of radon and thoron progeny and Long-Lived Radioactive Dust (LLRD).

The CAIRS measuring head is in essence, an alpha particle spectrometer capable of detecting separately, without electronics, the 5.99 MeV and the 7.69 MeV alpha particles from radon progeny (Po-218 (RaA) and Po-214 (RaC')) and the 8.78 MeV alpha particle from thoron progeny (Po-212 (ThC')). The alpha particles are detected by the damage they create on a cellulose nitrate film.

Spectroscopic separation of the alpha particles is achieved by using a three-channel collima-tor. Each channel contains an energy-absorbing piece of mylar whose thickness is chosen specifically for the alpha particle it is designed to identify. The design is such that the three alpha particles of interest hit the cellulose nitrate film when their dE/dx (energy loss) is at a maximum (the "Bragg peak" in the dE/dx versus E curve). They produce easily-identifiable holes in the film after etching.

The following is a list of the technical characteristics of the CAIRS dosimeter head:

- High density polyethylene end cap, barrel, collimator and barrel holder;
- Filter used: 25 mm diameter, 1.2 μm pore size;
- Film used: Kodak cellulose nitrate LR-115 Type II film;
- Absorbers used: Mylar absorbers;
- Diameter: 37 mm;
- Height: 43 mm;
- Weight: 21 g.

PAD OPERATION

In the operation of the CAIRS-ALGADE Personal Alpha Dosimeter, the ALGADE sampler draws air through the CAIRS dosimeter head at a nominal air flow rate of 4 l/h. Any attached radon and thoron progeny and LLRD in the air will become trapped on the filter inside the measuring head.

As the radon and thoron progeny and LLRD decay, alpha radiation is emitted. Some of the alpha radiation given off from the filter will travel up the three-channel collimator and pass through the absorbers attached to the collimator. Any alpha particles making it through the absorbers will strike the detector film located on top of the collimator. The detector film (LR-115 Type II) used in the dosimeter head is sensitive to alpha radiation, provided that the alpha particles have an energy of approximately 2.7 MeV.

To obtain the desired energy discrimination between the different alpha particles, each collimator is fitted with a mylar absorber of a specific thickness. The different thicknesses have been chosen so that the alpha particles of interest emerge from the mylar absorber with an approximate energy of 2.7 MeV. Other alpha particles will either be stopped by the absorber or pass through with an energy greater than the optimal 2.7 MeV required to leave clear uniform tracks on the film. All of the energy discriminated alpha particles emitted by the radon and thoron progeny are registered as tiny lines of damaged molecules on the film.

The tracks on the film are then enlarged by etching the films for 90 minutes in 2.5 normal sodium hydroxide (NaOH) solution at a temperature of 60 °C. This produces tiny holes or tracks in the opaque film which are approximately 5 μm in diameter. The enlarged tracks can then be counted using a microscope by placing a light source below the detector film. The LLRD deposited on the dosimeter head filter is counted together with a paired blank separately using a scintillation detector and an automatic sample changer system.

LONG-LIVED RADIOACTIVE DUST DETECTION

The CAIRS-ALGADE Personal Alpha Dosimeter also measures the presence of Long-Lived Radioactive Dust (LLRD). Any traces of LLRD present on the filter inside the CAIRS dosimeter head will remain there for extended periods and can be detected using conventional alpha radiation detectors.

Following a minimum waiting period to allow all radon and thoron December 8, 1995 progeny to decay, the gross alpha activity on the dosimeter head filter is measured using a Zinc Sulphide (ZnS) scintillation detector connected to a Ludlum Scalar/Ratemeter and a Nuclear Chicago sample changer. Each measurement of gross alpha activity on the dosimeter head filters is accompanied by a paired blank measurement to determine the corresponding number of background counts measured by the ZnS detector.

CAIRS PERSONAL ALPHA DOSIMETRY PROGRAM

The CAIRS-ALGADE Personal Alpha Dosimeter is worn daily by the individuals to be monitored. At the end of each working day, the PAD is placed into a charging unit overnight to recharge the ALGADE sampler battery. Radiation safety staff at the client work site are responsible for taking some of the necessary measurements required to determine the average air flow rates through the PADs.

At the end of each month, the CAIRS exposed dosimeter heads are removed from the ALGADE individual samplers and replaced with new dosimeter heads. The exposed dosimeter heads, together with PAD assignment and air flow rate information, are then returned to the CAIRS National Laboratories for processing. Monthly dosimetry reports are generated by CAIRS and distributed to the client.

CAIRS DOSIMETER HEAD TESTS

The CAIRS Dosimeter Heads are regularly tested in the CAIRS Calibration Chamber to ensure proper performance and accuracy. The tests involved the exposure of several dosimeter heads to radon progeny in the CAIRS Calibration Chamber. The dosimeter head results were compared to the CAIRS Reference Method (alphaNuclear alphaSMART 771 System) and manual Kusnetz Method samples.

The average percent difference between the CAIRS dosimeter head results in the CAIRS Reference Method results was 9%. The average percent difference between the CAIRS dosimeter head results and the Kusmetz Method results was 6%.

CAIRS also regularly participates in radon proficiency programs sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy Environmental Measurements Laboratory.