Sources

Americium-241
Alpha foil and sources for smoke detectors

Americium-241 (^{241}Am) alpha partical emitting foil, made by AEA Technology, is widely used in ionization chamber smoke detectors (ICSD). The foil combines high integrity of containment with high emission efficiency.

AEA Technology has over 30 years experience of foil technology and offers a well established standard product range of foil mounted in holders (sealed sources).

Construction

The radioactive material ^{241}Am emits alpha and low energy X- and gamma radiation. It is incorporated within a gold matrix and sandwiched between a silver backing and a palladium laminate, as illustrated schematically below. The face layer is thick enough to retain completely the ^{241}Am but thin enough to allow efficient emission of the α-radiation.

The shaped foil pieces are then mounted into various holders by staking, securing between spot welded metal plates or rolling over the holder edges.

AEA Technology has developed techniques for producing foil pieces cleanly, reproducibly and safely, and also for mounting them into holders to become sealed sources. Specialised equipment and appropriately licensed facilities are essential to both processes. It is strongly advised that these operations be carried out at our facilities.

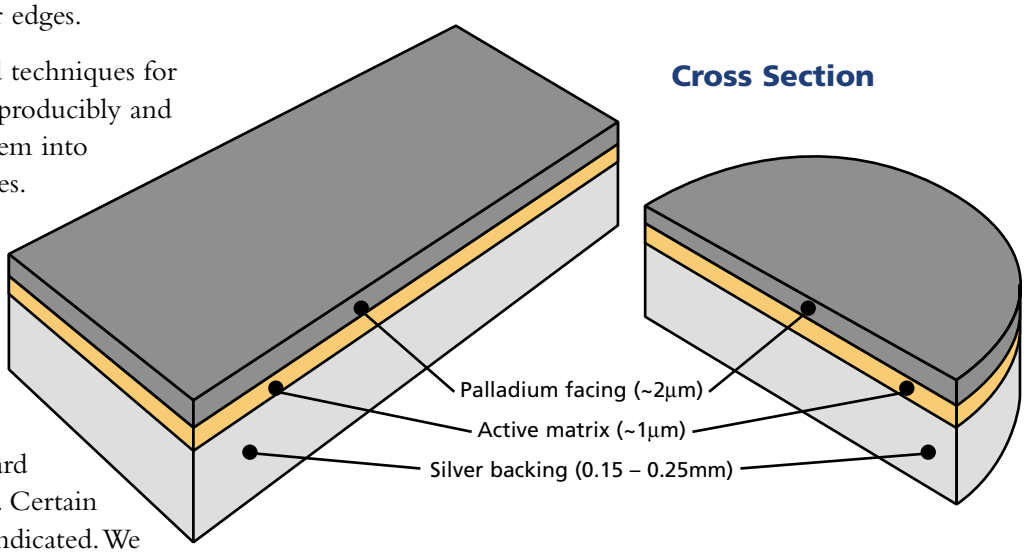
AEA Technology offers a standard product range of sealed sources. Certain foil pieces are also available as indicated. We welcome early discussions on new customer requirements.

Related Products

AEA Technology has a wide-ranging expertise in the design and construction of ionization chambers, built up over 30 years of experience in smoke detection. A consultancy service is offered for the design and/or manufacture of ionization chambers intended for use both in smoke detection and other applications.

A data sheet[1], 'Smoke Detector Ionization Chambers: DSCA2 and DSCA3' is available upon request.

Cross Section



High Tech Sources Limited
Unit 6, Moorbrook, Southmead Industrial Estate, Didcot, Oxon OX11 7HP
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

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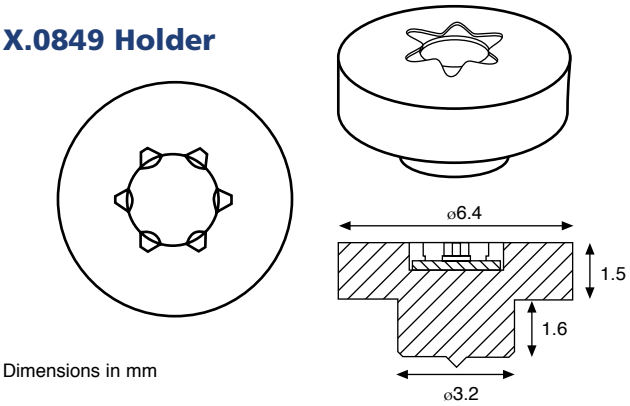
Sealed Sources

The use of sealed sources purchased directly from AEA Technology is strongly recommended. This avoids the need for customer located radioactive facilities for foil mounting, and handling is much simplified. These sources pass statutory leak tests and meet the requirements of regulatory authorities worldwide.

Six standard products are illustrated below.

X.0849 Holder

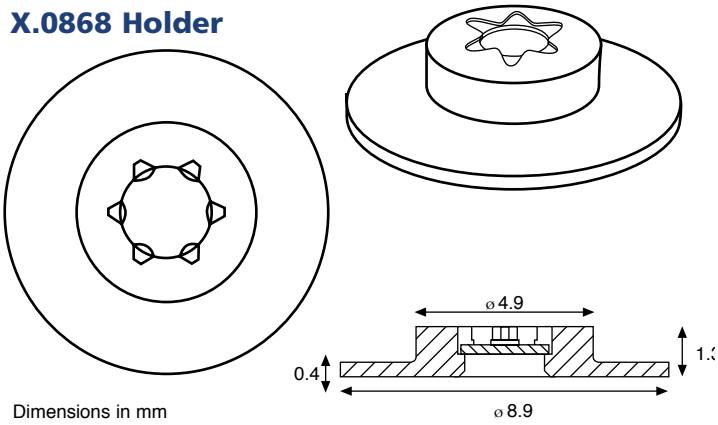


Dimensions in mm

Activity	Activity Tolerance	Product Code
18.5kBq (0.5µCi)	± 20%	AMMK7540
29.6kBq (0.8µCi)	± 20%	AMMK5597

Closure: staking
Quality control: wipe test A
Safety performance testing: BS/ISO/ANSI C64444; IAEA Special Form GB/367/S-85; RWL (10 years)

X.0868 Holder



Dimensions in mm

Activity	Activity Tolerance	Product Code
18.5kBq (0.5µCi)	± 20%	AMMK7648
29.6kBq (0.8µCi)	± 20%	AMMK1235

Closure: staking
Quality control: wipe test A
Safety performance testing: BS/ISO/ANSI C64444; IAEA Special Form GB/323/S-85; RWL (10 years)

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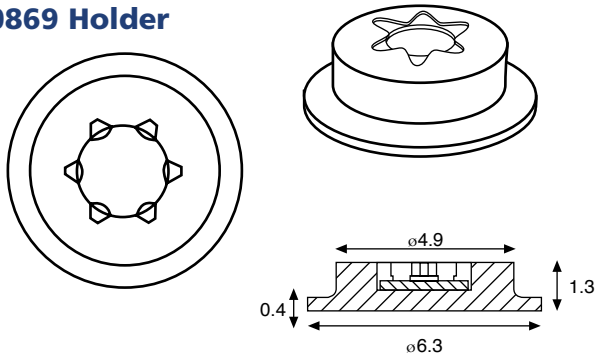
Unit 6, Moorbrook, Southmead Industrial Estate, Didcot, Oxon OX11 7HP
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

X.0869 Holder



Activity	Activity Tolerance	Product Code
18.5kBq (0.5µCi)	± 20%	AMMK7649
29.6kBq (0.8µCi)	± 20%	AMMK7650

Closure: rolling over the holder edge
Quality control: wipe test A
Safety performance testing: BS/ISO/ANSI C64444; IAEA Special Form GB/324/S-85; RWL (10 years)

AEA Technology has extensive experience of holder design and manufacture and is please to advise on any aspects of technical performance, safety, quality and service. Early consultation on new designs is welcomed.

Foil Pieces

Users of unmounted foil pieces must have specialised radioactive handling and testing facilities, which need to be licensed by an appropriate national regulatory authority.

Five foil piece types are presently available:

Activity	Activity Tolerance	Product Code	Size (mm)
18.5kBq (0.5µCi)	± 20%	AMMK7169	ø2.38
29.6kBq (0.8µCi)	± 20%	AMMK6045	ø2.38
18.5kBq (0.5µCi)	± 20%	AMMK5588	ø5.00
29.6kBq (0.8µCi)	± 20%	AMMK3457	ø5.00
18.5kBq (0.5µCi)	± 20%	AMMK7620	3.5 x 3.5

Safety performance testing: BS/ISO/ANSI C64444; IAEA Special Form GB/326/S-85; applicable to foil pieces greater than ø5mm.

Regulatory Compliance

AEA Technology foil meets the regulatory requirements of most national authorities worldwide.

AEA Technology ^{241}Am foil has been evaluated and registered by the US Nuclear Regulatory Commission (NRC). These registrations, now are under the jurisdiction of the Massachusetts Radiation Control Program. Registrations tabulated below, are recognized in the US as equivalent to NRC registrations and so has nationwide validity.

Foil for use in smoke detectors

	Model Number
Foil emitting one side only	AMM.1001
Foil emitting from both sides	AMM.1001D
Foil mounted in holder (i.e. sealed source)	AMM.1001H

When used as part of single station smoke detectors, AEA Technology sealed sources are also fully compatible with the requirements of:

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– Underwriters Laboratories Standard UL 217[2]
– European Norm EN 54[3]
– UK National Radiological Protection Board (NRPB) criteria of acceptability[4] upon which intended UK overnment legislation relating to smoke detectors is to be based.

Quality Assurance

ISO 9001 conformity

The design, manufacture and testing of AEA Technology Americium-241 foils is managed within the scope of the Q&SA Quality Management System which is approved by Lloyds Register Quality Assurance for compliance with BS EN ISO 9001:1994.[5]

Quality Control

Surface contamination

Sealed sources: Sealed sources are batch tested in conformity with BS 5288[6]. External surfaces, including the alpha-emitting faces, are wiped with a swab of tissue or cottonwool moistened with methanol or water. Any activity removed is measured by a liquid scintillation counting technique. The acceptance criterion is <185Bq (0.0005μCi).

Foil pieces: Although AEA Technology's techniques minimize the amount of removable surface contamination, unmounted foil cannot be designated as sealed sources. The tests used to check for surface contamination will depend on the size, shape and quantity of the pieces. The tests may be varied to suit user requirements. Further details are available on request.

Measurement

To control the content of individual foil pieces, the radioactive content of all rolled foil, and hence the final activity per unit area, is measured using a high sensitivity solium iodide crystal.

Depending on user requirements and quantities involved, it is possible to offer the following additional measurements:

– activity content of individual sealed sources or foil pieces
– batch spectrometry showing typical emitted energy distribution
– full-width half-maximum values determined from spectrometry, ie the energy banwith at half the maximum intensity value
– spatial distribution – the measured intensity along the 2 pi arc above the emitting surfaces from a given batch
– ion current as measured in an ionization chamber with an agreed specific geometry
– acceptable quality level (AQL)

Safety Performance

ISO 2919 classification

Source performance under working conditions is tested in accordance with internationally defined (ISO) standards. Please refer to the AEA Technology document 'Safety and Packaging'(7) for details of the test data and system of classification.

The ISO rating recommended for ionization chamber smoke detector sources is C32222. By use of optimum design parameters, the performance of AEA Technology's sealed sources significantly exceeds this in all cases, as indicated above.

Special Form Tests

AEA Technology sources have passed the tests for Special Form radioactive material as specified in IAEA transport regulations(8). The AEA Technology document 'Safety and Packaging'(7) gives further information about IAEA Special Form.

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Unit 6, Moorbrook, Southmead Industrial Estate, Didcot, Oxon OX11 7HP
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

Other tests

Many other test designed to simulate severe industrial environments have been performed on samples of alpha foil, including exposure to sulphur dioxide gas, to salt spray and to ozone. Details of such tests can be supplied on request.

National radiation regulations[9], in common with other national regulations, require that radioactive sources should not be handled with bare fingers. They must be handled using forceps, vacuum pick-up or protective gloves, taking care not to damage the emitting face. For sealed sources these simple procedures are generally adequate, though other mechanical systems may be used if required.

Considerable additional safety precautions are required for the processing of unmounted foil pieces. Users may contact AEA Technology or the competent national authority for advice on particular operations but it is recommended that such operations be entrusted to AEA Technology which has extensive experience of all aspects of foil handling.

External radiation attributable to the ^{241}Am sealed source in an ICSD is normally extremely low. The following approximate dose rate calculations based on thermoluminescent dosimetry data derived in respect of a typical AEA Technology ICSD are given for guidance. These data will enable users to comply with the US Code of Federal Regulations [10 CFR.32.26.(6).]

Directions	Distance (cm)	Dose rate mSv/year	Dose rate rem/year
Normal to surface of outer cap electrode	5	0.1	0.01
Normal to surface of outer cap electrode	25	0.005	0.0005
Normal to source electrode	5	0.6	0.06
Normal to source electrode	25	0.03	0.003

By comparison, the background dose rate in the UK can typically be 2mSv/year (0.2rem/year).

Reference may also be made to the AEA Technology 'Safety and Packaging' document[7]. For any other safety advice please enquire as above.

Recommended Working Life

The recommended working life (RWL) of AEA Technology's sealed sources when used in dry, non-corrosive atmospheres is 10 years. Please refer to our 'Safety and Packaging' document[7] for further explanatory details.

An RWL cannot be assigned to sources used in any other environment nor to any foil which is to be further processed by the customer. However, advice on such cases may be sought through your local Sales Office.

Nuclear Data for ^{241}Am used in AEA Technology Foil

Half-life	Principal alpha particle energies	Principal photon partide energies	Radionuclidic purity
433 years	5.338 MeV 1.4%	59.5kV (36%)	<0.5% ^{243}Am
	5.445 MeV 12.8%	Np L X-rays	<0.0001% other
	5.486 MeV 85.2%	12-22keV (~40%)	gamma impurities
	Others Low		
Chemical purity >99%			

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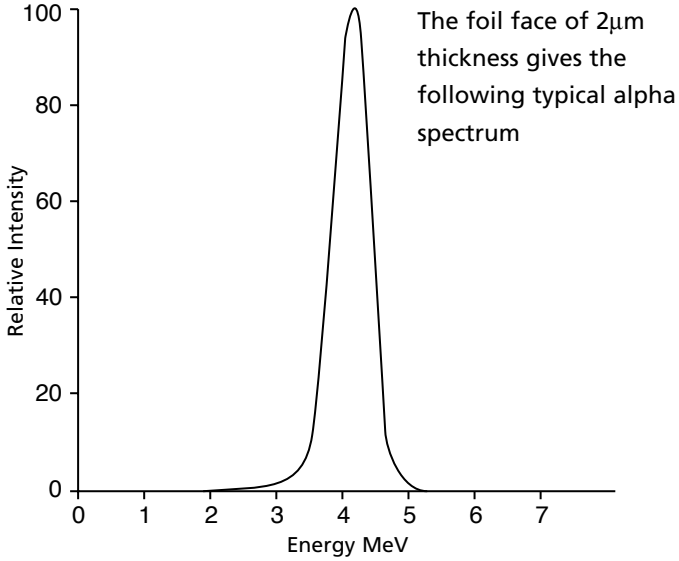
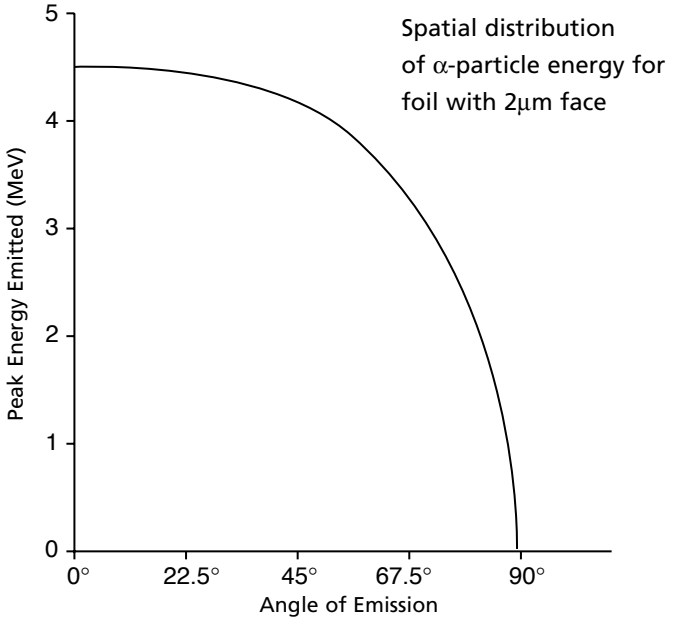
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk



The foil face of 2μm thickness gives the following typical alpha spectrum



Spatial distribution of α-particle energy for foil with 2μm face

References

1. 'Smoke Detctor Ionization Chambers: DSCA2 and DSCA3.' Data Sheet No 11247, AEA Technology, 1997.
2. 'Standard for Single and Multiple Station Smoke Detectors.' UL 217, Fourth Edition, Underwrites Laboratories Inc., Northbrook, Illinois, 10th May 1993.
3. 'Components of Automatic Fire Detection Systems.' EN 54, European Commission for Standardization (CEN), Brussels, July 1982.
4. 'Board Statement on Approval of Consumer Goods Containing Radioactive Substances.' Documents of the NRPB, Volume 3, No. 2, National Radiological Protection Board, Didcot, 1992.
5. 'Quality systems: Model for quality assurance in desgin, development, production, installation and servicing.' BS EN ISO 9001, British Standards Institution, London, 1994.
6. 'Specification - sealed radioactive sources.' BS 5288, British Standards Institution, London 1976.
7. 'Safety and Packaging.' Data sheet reference SOU/120/95/KI, AEA Technology, 1995.
8. 'IAEA Safety Standards: Regulations for the Safe Transport of Radioactive Materials, 1985 Edition. As Amended 1990.' International Atomic Energy Authority, Vienna, 1990.
9. 'The Ionising Radiations Regulations 1985.' Statutory Instrument 1985 No. 1333: Health and Safety, Her Majesty's Stationery Office, London, 1990.

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Unit 6, Moorbrook, Southmead Industrial Estate, Didcot, Oxon OX11 7HP
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

Sources

Smoke detector ionization chambers type DSCA2 and DSCA3

General description

Both products from AEA Technology incorporate a dual ionization chamber of advanced design containing a single radioisotope source producing ionization in both chambers. The design was developed using a computer model to optimize performance characteristics. A performance test electrode is incorporated in the DSCA3. Certain aspects of the designs, including the test electrode, are patented.

The design, manufacture and testing of the DSCA2 and DSCA3 ion chamber is managed within the scope of AEA Technology Quality System which is certified by Lloyds REgister Quality Assurance for compliance with BS EN ISO 9001:1994.[1]

The general construction is designed to meet the requirements of Underwriters Laboratories Inc. Standard UL 217[2] and EN 54:part 7.[3]

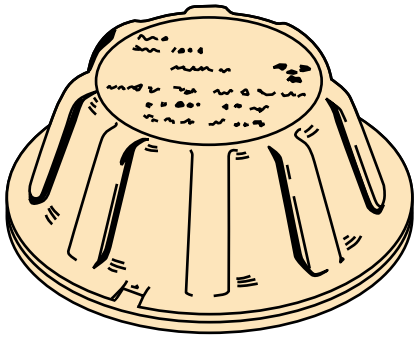
For maximum corrosion resistance the electrodes and source holder are made of AISI 316 stainless steel, the support moulding of polypropylene and the insulators of polytetrafluoroethylene Teflon™.

Details of the sealed source are given in the data sheets 'Americium-241 alpha foil and sources'[4] and 'Safety and Packaging'[5], both available on request. In accordance with OECD requirements[6] the source activity is less than 37kBq (1μCi) ^{241}Am. The Recommended Working Life of the source is 10 years. The BS/ISO/ANSI rating of the ionization chamber is C64646.

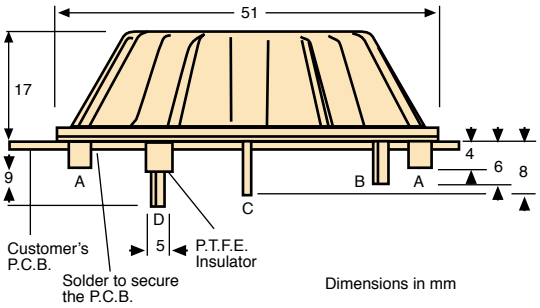
The units as supplied are assembled ready to mount on a suitable printed circuit board using the pre-tinned tags provided. No source adjustment is required.

The DSCA3's test electrode permits the checking not only of the operational functioning of the ion chamber but of all associated electronic circuitry. When actuated,

DSCA3

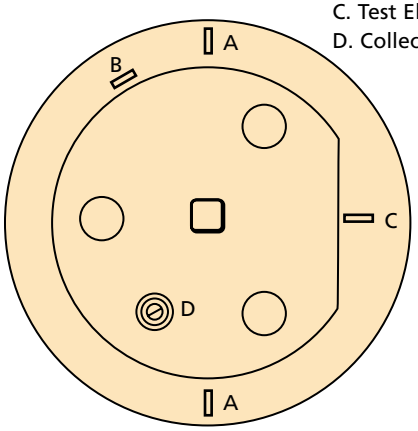


Side View



View from Underneath

A. Outer Cap Electrode
B. Source Plate Electrode
C. Test Electrode
D. Collector Electrode



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Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

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the electrode disturbs the balance conditions to simulate the presence of smoke by an obscuration of 4.0%/Ft.

The design is compatible with commercially available integrated circuits. A list of recommended circuits for use in smoke detectors is available on request.

AEA Technology expertise in the design and construction of ion chambers is long established and wide-ranging. A consultancy service is available to assist in the design of systems using ion chambers.

Regulatory Compliance

AEA Technology sealed foil sources used in the detectors meet the regulatory requirements of most national authorities worldwide. Virtually all ionization smoke detectors use such sealed sources.

Specifically AEA Technology sources comply with:

– Underwriters Laboratories Inc. Standard UL 217[2]

– European Norm EN 54[3]

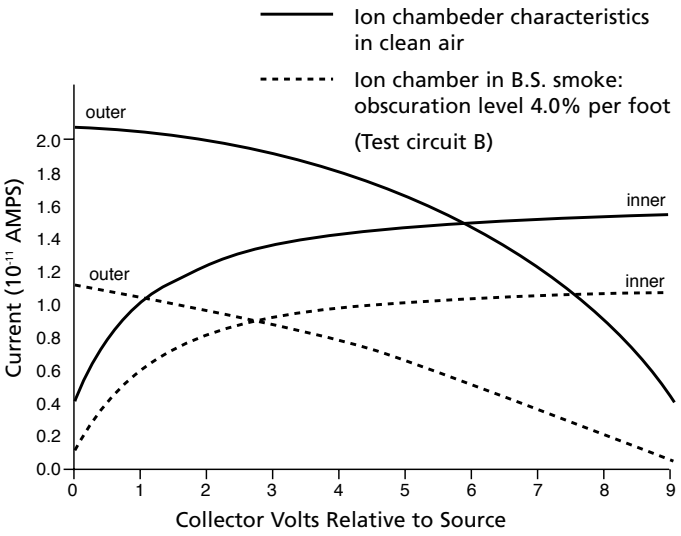
– Uk National Radiological Protection Board (NRPB) criteria of acceptability[7] upon which intended UK government legislation relating to smoke detectors is to be based.

– Performance criteria of Massachusetts Radiation Control Program where they have been registered under model number AMM.1001H. Registrations are recognised in the US as equivalent to NRC registration and so have nationwide validity.

Principle of Operation

The collector electrode is charged by any imbalance in the ionization currents flowing in the inner and outer chambers, until these currents come into balance. In the absence of smoke or combustion products, the balance potential remains constant, apart from small variations due to statistical fluctuation of the ionization current. In the diagram, this balance potential is illustrated by the crossover point of the continuous lines.

When smoke enters the chambers the ionization currents change, that in the outer chamber more so than in the inner camber. The collector electrode is then charged to a new balance potential as shown by the crossing of the two broken lines. The change in potential is used to trigger an alarm circuit.



Variation with ambient and other parameters are illustrated in Appendix 1.

The performance of the DSCA3 has been independently assessed in the following two studies:

– in smoldering smoke and fire tests by Underwriters Laboratories Inc[8]

– in accordance with a 'Testing Programme for Automatic Fire Alarm Equipment for Residential Use' by the Danish Research Centre for Applied Electronics[9]

Copies of both reports are available on request.

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Unit 6, Moorbrook, Southmead Industrial Estate, Didcot, Oxon OX11 7HP
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

Precautions and Recommendations

The ionization current is approximately 20 pA. Precautions to preserve the insulation of the input connection path to the electronics are critical for correct operation of the device. In particular the collector electrode and its connections must remain free from contamination, e.g. from solder flux or manual contact. The lead from the collector electrode to the detector circuit should preferably be short and clear of the circuit board and other components.

The chamber is shielded from external electric fields by its outer cover. Suitable shielding should be provided for the associated circuitry, because of the necessarily high impedance of the circuit connected to the chamber collector electrode.

To improve corrosion resistance, the associated circuitry should be sealed in a container, using a suitable sealant where the chamber terminals enter the chamber (avoiding sealant on the collector electrode insulator).

Chambers intended for use a high altitudes may require adjustment of the tripping level of the detector circuit for optimum sensitivity.

Within reasonable limits, the balance potential remains relatively unaffected by temperature, humidity and wind velocity, as shown on the following pages. AEA Technology can advise on applications in which the ion chamber may operate outside the ambient ranges illustrated.

Specification

The general specification is tabulated below. Conditions, except where specified, are:

– Outer electrode to source electrode potential: 9V

– Temperature: 20°C ± 3°C

– Ambient pressure: atmospheric, near sea level, clean air

	Minimum	Typical	Maximum	Units
Collector electrode balance potential	5.0	–	6.0	V
Change in collector balance potential with smoke:				
at 0.2% obscuration/foot*	–	0.7	–	V
at 4.0% obscuration/foot*	–	3.0	–	V
Insulator leakage	–	–	0.5	pA
Capacitance (collector to outer + source electrode)	–	6	–	pF
^{241}Am activity	–	20	26	kBq
	–	0.5	0.7	µCi

*obscuration limits specified by UL 217[2]

Radiological data

Users of these units in all countries should ensure that they comply with all relevant regulations on the control of radioactive materials.

The DSCA3 unit has been independently assessed and found satisfactory in the following respects:

– a general Radiological Assessment by the NRPB(10)

– an NEA 1200°C incineration test by the NRPB[11]

Copies of the NRPB reports are available on request.

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Unit 6, Moorbrook, Southmead Industrial Estate, Didcot, Oxon OX11 7HP
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

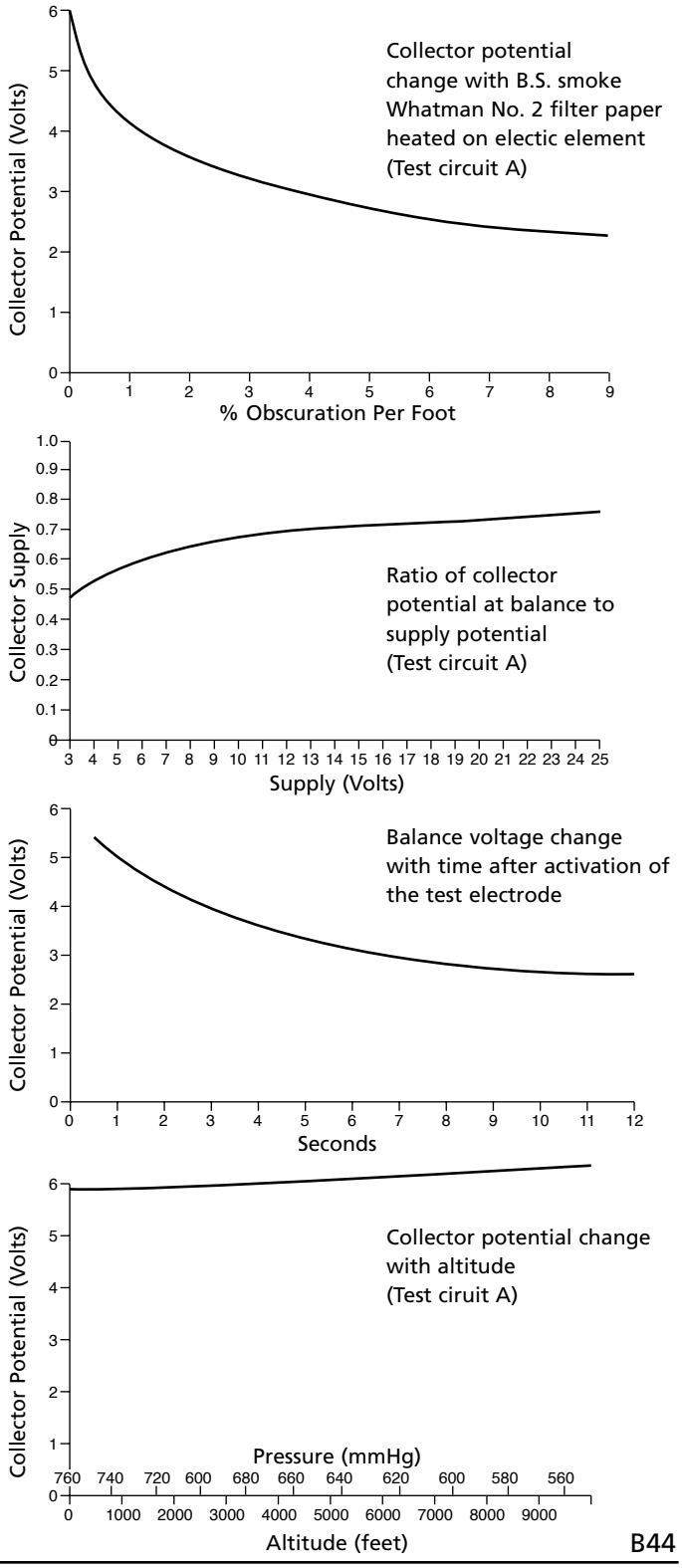
In both devices, external radiation attributable to the ^{241}Am sealed source is normally extremely low. The following approximate dose rate calculations based on thermoluminescent dosimetry data derived in respect of a typical AEA Technology unit are given guidance. These data will enable users to comply with the US Code of Federal Regulations [10 CFR.32.26(6).]

Direction	Distance (cm)	Dose Rate mSv/year	rem/year
Normal to surface of outer cap electrode	5	01.1	0.01
Normal to surface of outer cap electrode	25	0.005	0.0005
Normal to source electrode	5	0.6	0.06
Normal to source electrode	25	0.03	0.003

By comparison, a background dose rate in the UK can typically be 2mSv/year (0.2rem/year).

Reference may also be made to the AEA Technology 'Safety and Packaging' document[5]. For any other safety advice please enquire as above.

Performance



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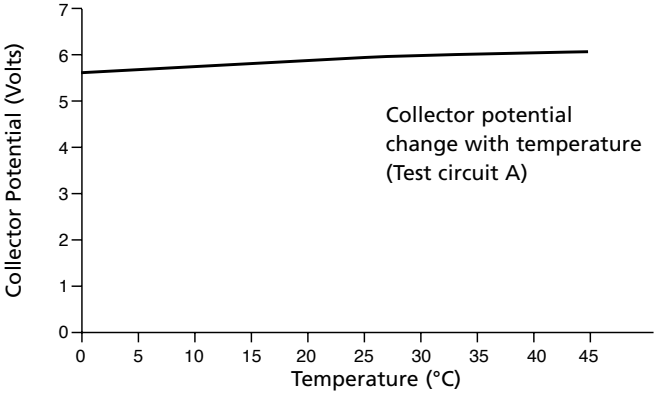
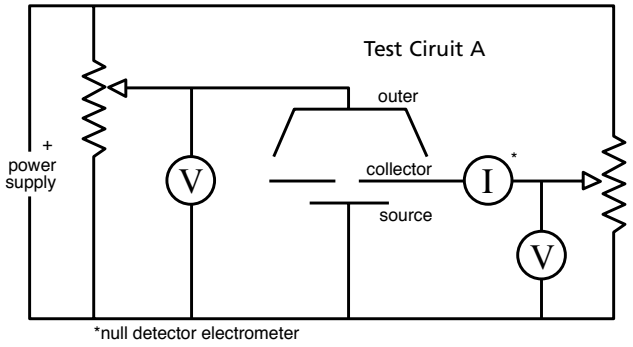
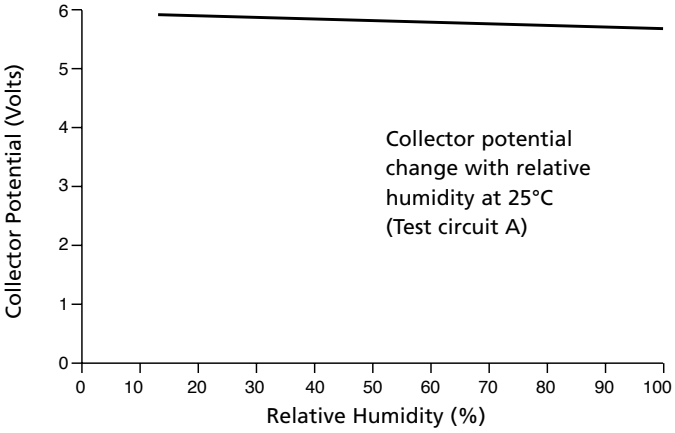
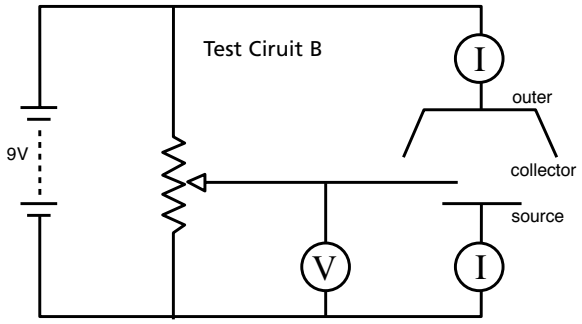
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

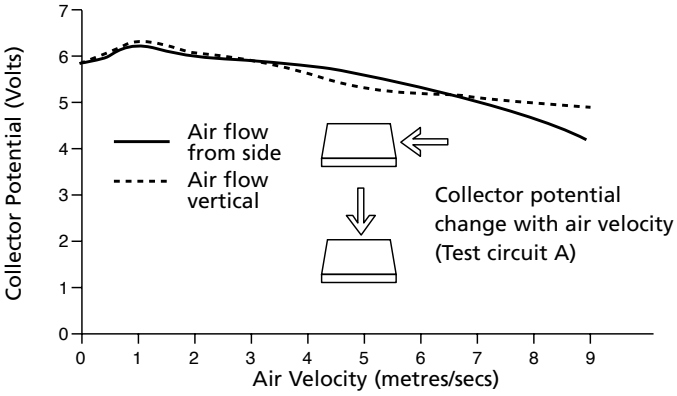


Ciruits used to determine typical characteristics









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Unit 6, Moorbrook, Southmead Industrial Estate, Didcot, Oxon OX11 7HP
Tel: 01235 514200 Fax: 01235 514219 e-mail: info@hightechsource.co.uk

References

1. 'Quality systems: Model for quality assurance in design, development, production, installation and servicing.' BS EN ISO 9001, British Standards Institution, London, 1994.
2. 'Standard for Single and Multiple Station Smoke Detectors.' UL217, Fourth Edition, Underwriters Laboratories Inc., Northbrook, Illinois, 10th May 1993.
3. 'Components of automatic fire detection systems.' EN 54: Part 7, European Commission for Standardization (CEN), Brussels, July 1982.
4. 'Americium-241 alpha foil and sources.' Data Sheet No. 11262, AEA Technology, 1997.
5. 'Safety and Packaging.' Data sheet reference SOU/120/95/KL, AEA Technology, 1995.
6. 'Recommendations for ionization chamber smoke detectors in implementation of radiation protection standards': Section 6 Nuclear Energy Agency, Organisation for Economic Co-operation and Development, Paris, 1977.
7. 'Board Statement on Approval of Consumer Goods Containing Radioactive Substances.' Documents of the NRPB, Volume 3, No. 2, National Radiological Protection Board, Didcot, 1992.
8. 'Smoldering Smoke And Fire Tests for Model DCS.A3.' S2182 78NK7050, Underwriters Laboratories Inc., Northbrook, Illinois, 22nd August 1978.
9. 'Informative Test of AFAR-Equipment.' Report No. 324323, Elektronikcentralen: Danish Research Centre for Applied Electronics, Copenhagen, 10th April 1979.
10. 'Measurement Report: Radiological Assessment.' EMR/1 34/79, National Radiological Protection Board, Didcot, 1979.
11. 'Analytical Report: NEA 1200°C incineration test.' NRPB/CP 3/016, National Radiological Protection Board, Leeds, 1985.

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