SAIC-89/8000

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

Received w/Ltr Dated . 8/30/88

Part II

# YUCCA MOUNTAIN PROJECT

# RADIOLOGICAL FIELD PROGRAMS CALIBRATION DOCUMENT MANUAL

MAY 1989

UNCONTROLLED

102

WORK PERFORMED UNDER CONTRACT NO. DE-AC08-87NV10576

Technical & Management Support Services

SAIC

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

9007120245

CALIBRATION DOCUMENT MANUAL

Issued by the
T&MSS Radiological Field Programs Division

Issued on 5/26/89

Manager, Radiological Field Programs Division

UNCONTROLLED

9007120245 880831
PDR WASTE
WM-11 PDC

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| a. Detector Model 44-6, Serial Number PR054388 (beta-gamma) | None | |
| 2. Serial Number 62643 | | |
| a. Detector Model 44-6, Serial Number PR054387 (beta-gamma) | None | |
| B. Ludlum Model 12 | | |
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| | | | |
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| | b. Detector Model HP-260, Serial Number 704260 (gamma/beta) | 4/21/89 | 3 |
| 2. | Serial Number 1859 | 10/25/88 | |
| | a. Detector Model HP-260, Serial Number 701304 (gamma/beta) | 10/25/88 | |
| | b. Detector Model HP-260, Serial Number 704260 (gamma/beta) | 10/25/88 | 3 |

II. Radiation Detection Instrument (Alpha only)

A. Ludlum Model 65

| | | | |
|---|---|---|---|
| 1. | Serial Number 60879 (alpha) | 1/31/89 | 4 |
| 2. | Serial Number 48432 (alpha) | 1/24/89 | 4 |

III. Radiation Detection Instruments (Dose Rate)

A. Ludlum Model 19

| | | | |
|---|---|---|---|
| 1. | Serial Number 62596 (gamma) | 1/31/89 | 2 |
| 2. | Serial Number 62550 (gamma) | 1/31/89 | 2 |

IV. Radiation Sources

A. Alpha

| | | | |
|---|---|---|---|
| 1. | Thorium-230 | | |
| | a. 6.22E-05 microcuries, Serial Number TH4700205 | 1/10/89 | 1 |
| | b. 6.55E-3 microcuries, Serial Number 88TH2201990 | 5/25/88 | 1 |
| | c. 1.61E-4 microcuries, Serial Number 87TH2200849 | 12/1/87 | 1 |

B. Beta

| | | | |
|---|---|---|---|
| 1. | Strontium-90--Yttrium-90 | | |
| | a. 5.76E-05 microcuries, Serial Number SR4700206 | 1/10/89 | 1 |

C. Gamma

| | | |
|---|---|---|
| 1. Europium-152 | | |
| a. 0.609 microcuries, Serial Number AR 716 | 1/13/88 | 2 |
| 2. Barium-133 | | |
| a. 0.9249 microcuries, Serial Number AT 500 | 3/24/88 | 2 |
| 3. Cobalt-57 | | |
| a. 1.095 microcuries, Serial Number AT 502 | 3/3/88 | 2 |
| 4. Caesium-137 (Cesium) | | |
| a. 0.9757 microcuries, Serial Number AT 500 | 3/24/88 | 2 |
| 5. Cobalt-60 | | |
| a. 1.038 microcuries, Serial Number AT 503 | 3/24/88 | 2 |
| 6. Manganese-54 | | |
| a. 0.781 microcuries, Serial Number AT 504 | 3/25/88 | 2 |
| 7. Mercury-203 | | |
| a. 1.79 microcuries, Serial Number AT 505 | 3/25/88 | 2 |
| 8. Sodium-22 | | |
| a. 1.034 microcuries, Serial Number AT 506 | 3/31/88 | 2 |
| 9. Yttrium-88 | | |
| a. 0.951 microcuries, Serial Number AT 507 | 3/29/88 | 2 |

D. Mixed Sources

| | | |
|---|---|---|
| 1. Gamma | | |
| a. Cd-113m <6E-5, Co-56 <6.6e-6, Co-58 <2.7E-6, Rb-86 <6-6E-6, Zn-65 <1.3E-5 microcuries, Serial Number 1410QB | 10/1/87 | 1 |

E. Radon Sources

| | | |
|---|---|---|
| 1. Pylon RNC Source, Ra-226 | | |
| a. 2,500 picocuries, Serial Number 102 | 2/28/87 | 2 |
| 2. Pylon 47mm Radon Daughter Standard (RN-190), Ra-226 | | |
| a. 2.004E-3 microcuries/$cm^2$ (at equilibrium), Serial Number 121 | 9/26/86 | 3 |

V. Air Flow

A. RADeCO Air Flow Calibrator Model C-812,

| | | |
|---|---|---|
| 1. Serial Number 1549 | 6/6/89 | 1 |

B. Kurz Mass Flow Meter Model 1544,

| | | |
|---|---|---|
| 1. Serial Number MBE 1565N | 8/18/88 | 3 |

C. Kurz Mass Flow Meter Model 490,

| | | |
|---|---|---|
| 1. Serial Number LVE3179I | 8/18/88 | 4 |

D. Anderson Constant Air Flow Pump, Model SE112

| | | |
|---|---|---|
| 1. Serial Number 785-372 | 9/22/87 | 1 |
| 2. Serial Number 785-371 | 9/22/87 | 1 |

VI. Mass/Volume/Length

VII. Temperature/Barometric Pressure/Humidity

| | | |
|---|---|---|
| A. Thermometer, Serial Number N-67692 | 10/28/87 | 1 |

VIII. Electronic/Electrical

A. Pulser/Signal Generator

1. Ludlum Model 500 Pulser

| | | |
|---|---|---|
| a. Serial Number 61737 | 1/11/89 | 3 |

2. B&K Signal Generator, Model 3020

| | | |
|---|---|---|
| a. Serial Number 89-19309 | 2/21/89 | 2 |

B. Oscilloscope

1. B&K Oscilloscope, Model 1590A

| | | |
|---|---|---|
| a. Serial Number 02416 | 2/21/89 | 2 |

C. Voltmeters/Ampmeters/Ohmmeters

1. B&K Volt/Amp/Ohm meter, Model 8024B

| | | |
|---|---|---|
| a. Serial Number 4480363 | 2/20/89 | 3 |

D. Voltage/Current Sources

1. B&K Voltage/Current Supply, Model 1601

| | | |
|---|---|---|
| a. Serial Number 24-32603 | 2/21/89 | 2 |

IX. Other

Issued By

Date 6/9/89

# I. Radiation Detection Instruments (count rate)

# A. Ludlum Model 3

Ludlum Model 3

Serial Number 62317

Detector Model 44-6/Serial Number PR54388

None.

Ludlum Model 3

Serial Number 62643

Detector Model 44-6/Serial Number PR54387

None.

## B. Ludlum Model 12

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

## CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 12 Serial No. 59298
Mfg. " Det. Model 43-44 Serial No. 60923
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1 yr METERFACE 202-356
Check mark ( ✓ ) applies to applicable instr. and/or detector IAW mfg. spec. s. ☑ New Instrument
☑ Det. (Alpha) Bkgnd 0 cpm ☑ Det. Oper. V 2000 V at 2 MV
Temp. 75° Humidity 50 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 2.2 VDC ☐ Bat. Volt VDC Instrument Volt Set 2000 V
☐ Threshold Dial Input Sens 2 mV. ☐ Input Sens Linearity
☑ HV Readout (2 points) Ref./Inst 500 / 500 V Ref./Inst 1965 / 2000 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:
With Th230 ≅ 1200 dpm check source (s/n 207) instrument reads 120cpm.
Instrument voltage set for 2000 ft. Alt.

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 1000 | 300Kcpm | 300 | |
| x 100 | 30 " | 300 | |
| x " | 20 " | 200 | |
| x " | 10 " | 100 | |
| x 10 | 3 " | 300 | |
| x 1 | 300cpm | 300 | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |

All Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1963

☑ Alpha s/n 8743 ☐ Beta s/n ☐ Other

☑ M-500 s/n 18475 ☐ Oscilloscope s/n ☑ Multimeter s/n 32733

Calibrated By: Michael Gaston Date 1-30-89

Reviewed By: Larry Bell Date 1-31-89

Form 22 — 3/88

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

**LUDLUM MEASUREMENTS, INC.**
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

Bench Test Data For Detector m 43-44 S/N 60923

Customer SAIC Order No. 88-4867

Counter m 12 S/N 59798 Distance-Source to Detector Surface

Count Time cpm Counter Input Sensitivity 2 mv

Isotope Pu 239 S/N 8743 Size 12,800 cpm/2π Other

**43-4/43-44 HV ADJ FOR ALTITUDE**

| ALT. | HIGH VOLTAGE |
|---|---|
| Sea Level | 2050 V |
| 1000 foot | 2025 V |
| 2000 foot | 2000 V |
| 3000 foot | 1975 V |
| 4000 foot | 1950 V |
| 5000 foot | 1925 V |
| 6000 foot | 1900 V |
| 7000 foot | 1875 V |
| | |

**ALPHA SCINTILLATION DETECTOR**

| HV Plateau | Background | Source Count |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

OPERATING VOLTAGE SET AT 2000 V

| AIR PROPORTIONAL | 43-5 | 43-65 | BACKGROUND | METER READING | RANGE/SCALE |
|---|---|---|---|---|---|
| | Toe | L/S * | | | |
| 43-44 | Center | Center | 0 | 260 | X10 |
| | Heel | Other ** | | | |

☐ Uniformity (± 10%) Ave. Efficiency 20.3 %

* Least Sensitive Position (Heel Of Probe)

** Opposite Least Sensitive Position (Top Of Probe)

Date 1-30-89 Signature Michael Gaston

Form 21 3/88

B

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890125-65 LUDLUM ORDER # 88-4867

CATALOG # 48-1609, 47-1169 MODEL & SERIAL # M12 #59798, M43-44 #60923

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM #1
REQUIREMENT I

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

## CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 12 Serial No. 51999
Mfg. " Det. Model 43-44 Serial No. 60978
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1 yr METERFACE 202-356
Check mark ( ✓ ) applies to applicable instr. and/or detector IAW mfg. spec. s. ☑ New Instrument
☑ Det. (Alpha) Bkgnd 0 cpm ☑ Det. Oper. V 2000 V at 2 MV
Temp. 75° Humidity 56 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 2.2 VDC ☐ Bat. Volt VDC Instrument Volt Set 2000 V
☐ Threshold Dial Input Sens. 2 mV. ☐ Input Sens Linearity
☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1925 / 2000 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:
with Th230 ≅ 700dpm check source (s/n 209) instrument reads 60cpm.
Instrument voltage set for 2000 ft. Alt.

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-4 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 1000 | 300 Kcpm | 300 | |
| x 100 | 30 " | 300 | |
| x " | 20 " | 200 | |
| x " | 10 " | 100 | |
| x 10 | 3 " | 300 | |
| x 1 | 300 cpm | 300 | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |

All Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1968

☑ Alpha s/n 8743 ☐ Beta s/n ☐ Other

☑ M-500 s/n 18475 ☐ Oscilloscope s/n ☑ Multimeter s/n 32733

Calibrated By: Michael Gaston Date 1-30-89

Reviewed By: Doug Bell Date 1-31-89

Form 22 — 3/88

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

Bench Test Data For Detector m 43-44 S/N 60978

Customer SAIC Order No. 88-4867

Counter m 12 S/N 51999 Distance-Source to Detector surface

Count Time cpm Counter Input Sensitivity 2 mv

Isotope Pu-239 S/N 8743 Size 12,800 cpm (2π) Other

**43-4/43-44 HV ADJ FOR ALTITUDE**

| ALT. | HIGH VOLTAGE |
|---|---|
| Sea Level | 2050 V |
| 1000 foot | 2025 V |
| 2000 foot | 2000 V |
| 3000 foot | 1975 V |
| 4000 foot | 1950 V |
| 5000 foot | 1925 V |
| 6000 foot | 1900 V |
| 7000 foot | 1875 V |
| | |

**ALPHA SCINTILLATION DETECTOR**

| HV Plateau | Background | Source Count |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

OPERATING VOLTAGE SET AT 2000 V

| AIR PROPORTIONAL | 43-5 | 43-65 | BACKGROUND | METER READING | RANGE/SCALE |
|---|---|---|---|---|---|
| | Toe | L/S * | | | |
| 43-44 | Center | Center | 0 | 270 | X10 |
| | Heel | * * Other | | | |

☐ Uniformity (± 10%) Ave. Efficiency 21 %

* Least Sensitive Position (Heel Of Probe)

* * Opposite Least Sensitive Position (Top Of Probe)

Date 1-30-89 Signature Michael Gaston

Form 21 3/88

D

DESIGNER AND MANUFACTURER
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LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890125-65 LUDLUM ORDER # 884867

CATALOG # 48-1609, 47-1169 MODEL & SERIAL # M62 # 51999, M43-44 # 60978

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM # 4
REQUIREMENT II

Bill Huckabee

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

## CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 12 Serial No. 51998
Mfg. Det. Model 43-44 Serial No. 60921
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1yr METERFACE 20.2-356
Check mark ( ✓ ) applies to applicable instr. and/or detector IAW mfg. spec. s. ☑ New Instrument
☑ Det. (Alpha) Bkgnd 0 cpm ☑ Det. Oper. V 2000 V at 2 MV
Temp 75° Humidity 50 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 2.2 VDC ☐ Bat. Volt VDC Instrument Volt Set 2000 V
☐ Threshold Dial Input Sens 2 mV. ☐ Input Sens Linearity
☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1965 / 2000 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:
With Th230 ≅ 7.4 pCi/g check source (s/n 210) instrument reads 1800 cpm.
Instrument voltage set for 2000 ft. Alt.

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 1000 | 300 Kcpm | 300 | |
| x 100 | 30 " | 300 | |
| x " | 20 " | 200 | |
| x " | 10 " | 100 | |
| x 10 | 3 " | 300 | |
| x 1 | 300 cpm | 300 | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |

All Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1968
☑ Alpha s/n 8743 ☐ Beta s/n ☐ Other
☑ M-500 s/n 18475 ☐ Oscilloscope s/n ☑ Multimeter s/n 32733
Calibrated By: Michael Gaston Date 1-30-89
Reviewed By: Larry Bell Date 1-31-89

Form 22 — 3/88

DESIGNER AND MANUFACTURER
OF
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LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

Bench Test Data For Detector m 43-44 S/N 60921

Customer SAIC Order No. 88-4867

Counter m 12 S/N 51998 Distance-Source to Detector Surface

Count Time cpm Counter Input Sensitivity 2 mV

Isotope Pu 239 S/N 8743 Size 12,800 cpm (2π) Other

**43-4/43-44 HV ADJ FOR ALTITUDE**

| ALT. | HIGH VOLTAGE |
|---|---|
| Sea Level | 2050 V |
| 1000 foot | 2025 V |
| 2000 foot | 2000 V |
| 3000 foot | 1975 V |
| 4000 foot | 1950 V |
| 5000 foot | 1925 V |
| 6000 foot | 1900 V |
| 7000 foot | 1875 V |
| | |

**ALPHA SCINTILLATION DETECTOR**

| HV Plateau | Background | Source Count |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

OPERATING VOLTAGE SET AT 2000 V

| AIR PROPORTIONAL | 43-5 | 43-65 | BACKGROUND | METER READING | RANGE/SCALE |
|---|---|---|---|---|---|
| | Toe | L/S * | | | |
| 43-44 | Center | Center | 0 | 280 | X10 |
| | Heel | ** Other | | | |

☐ Uniformity (± 10%) Ave. Efficiency 21.9 %

* Least Sensitive Position (Heel Of Probe)

** Opposite Least Sensitive Position (Top Of Probe)

Date 1-30-89 Signature Michael Gaston

Form 21 3/88

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DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
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CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890125-65 LUDLUM ORDER # 884867

CATALOG # 48-1609, 47-1169 MODEL & SERIAL # M12 # 51998, M43-44 # 60921

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM # 4
REQUIREMENT II

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

## CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 12 Serial No. 51994
Mfg. Det. Model 44-9 Serial No. PR25-4433
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1yr METERFACE 202-356

Check mark ( ✓ ) applies to applicable instr. and/or detector IAW mfg. spec, s. ☑ New Instrument

☐ Det. (Alpha) Bkgnd ____ cpm ☑ Det. Oper. V 900 V at 35 MV

Temp 75° Humidity 50 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed

☑ Bat. ck. (Min. Volt) 2.2 VDC ☐ Bat. Volt ____ VDC Instrument Volt Set 900 V

☐ Threshold Dial ____ Input Sens. 35 mV. ☐ Input Sens Linearity

☐ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 2000 V

☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.

☐ Field Change Status ____

Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:
With Tc 99 ≈ 700dpm check source s/n 212. (source on surface of det.
With detector on 44-9 instrument reads 180cpm.
With detector on 44-40 instrument reads 140cpm.

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 1000 | 300Kcpm | 300 | |
| x 100 | 30 " | 300 | |
| x " | 30 " | 200 | |
| x | 10 " | 100 | |
| x 10 | 3 " | 300 | |
| x 1 | 300cpm | 300 | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |

All Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☑ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1963

☐ Alpha s/n ____ ☐ Beta s/n ____ ☐ Other ____

☑ M-500 s/n 18475 ☐ Oscilloscope s/n ____ ☑ Multimeter s/n 37733

Calibrated By: Michael L Austin Date 1-30-89

Reviewed By: Larry Bell Date 1-31-89

Form 22 — 3/88

DESIGNERS AND MANUFACTURERS
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890125-65 LUDLUM ORDER # 884867

CATALOG # 48-1609, 47-1539, 47-1538 MODEL & SERIAL # 12#51994, M44-9 # PR054433, M44-40 # PR054434

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM #5
REQUIREMENT #II

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

## CONVERSION CHART

CUSTOMER: SAIC Date 1-30-89

Order No. 88-4867 Model No. 12 S/N 51994

Source Cs 137 Detector Model 44-9 S/N PR054433

Size 1.5 Cm Ci H. V.: 900v

| Reference Point | Dial | Range/Scale |
|---|---|---|
| 200 mR/hr | 215 | X1000 |
| 150 " | 185 | " |
| 100 " | 145 | " |
| 50 " | 95 | " |
| 25 " | 490 | X100 |
| 15 " | 310 | " |
| 6 " | 130 | " |
| 2 " | 440 | X10 |
| 1 " | 240 | " |

Form 17

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 - 235-5494 - 235-4947 TELEX No. 406832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

## CONVERSION CHART

CUSTOMER: SAIC Date 1-30-89

Order No. 88-4867 Model No. 12 S/N 51994

Source Cs 137 Detector Model 44-40 S/N PR054434

Size 150 mG H. V.: 900v

| Reference Point | Dial | Range/Scale |
|---|---|---|
| 500 mR/hr | 180 | X1000 |
| 200 " | 100 | " |
| 150 " | 80 | " |
| 100 " | 55 | " |
| 50 " | 275 | X100 |
| 25 " | 150 | " |
| 15 " | 95 | " |
| 6 " | 340 | X10 |
| 2 " | 120 | " |
| 1 " | 70 | " |

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

## CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 12 Serial No. 51990
Mfg. " Det. Model 44-9 Serial No. PR054431
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1Yr METERFACE 202-356
Check mark (✓) applies to applicable instr. and/or detector IAW mfg. spec. s. ☑ New Instrument
☐ Det. (Alpha) Bkgnd ____ cpm ☑ Det. Oper. V 900 V at 3.5 MV
Temp 25-0 Humidity 50 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 2.2 VDC ☐ Bat. Volt ____ VDC Instrument Volt Set 900 V
☐ Threshold Dial ____ Input Sens. 35 mV. ☐ Input Sens Linearity
☑ HV Readout (2 points) Ref./Inst. 490 / 500 V Ref./Inst. 2020 / 2000 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status ____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:
With Tc 99 ≈ 1500 dpm check source s/n 211. (source on surface of det.
with detector nm 44-9 instrument reads 240 cpm.
With detector nm 44-40 instrument reads 200 cpm.

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 1000 | 300 Kcpm | 300 | |
| x 100 | 30 " | 300 | |
| x " | 20 " | 200 | |
| x " | 10 " | 100 | |
| x 10 | 3 " | 300 | |
| x 1 | 300 cpm | 300 | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |

All Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☑ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1963

☐ Alpha s/n ____ ☐ Beta s/n ____ ☐ Other ____

☑ M-500 s/n 18475 ☐ Oscilloscope s/n ____ ☑ Multimeter s/n 32733

Calibrated By: Michael Lawson Date 1-30-89

Reviewed By: [illegible] Date 1-31-89

Form 22 — 3/88

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

## CONVERSION CHART

CUSTOMER: SAIC Date 1-30-89

Order No. 88-4867 Model No. 12 S/N 51990

Source Cs 137 Detector Model 44-40 S/N PR054432

Size 150 mCi H. V.: 900v

| Reference Point | Dial | Range/Scale |
|---|---|---|
| 500 | 165 | X1000 |
| 200 | 90 | " |
| 150 | 75 | " |
| 100 | 55 | " |
| 50 | 270 | X100 |
| 25 | 150 | " |
| 15 | 90 | " |
| 6 | 320 | X10 |
| 2 | 120 | " |
| 1 | 70 | X1 |

Form 17

DESIGNER AND MANUFACTURER
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LUDLUM MEASUREMENTS, INC.
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POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

## CONVERSION CHART

CUSTOMER: SAIC Date 1-30-89

Order No. 88-4867 Model No. 12 S/N 51990

Source Cs 137 Detector Model 44-9 S/N PR054431

Size 150 mCi H. V.: 900v

| Reference Point | Dial | Range/Scale |
|---|---|---|
| 200 mR/hr | 200 | X1000 |
| 150 " | 170 | " |
| 100 " | 135 | " |
| 50 " | 85 | " |
| 25 " | 460 | X100 |
| 15 " | 310 | " |
| 6 " | 130 | " |
| 2 " | 440 | X10 |
| 1 " | 240 | " |

Form 17

13

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890125-65 LUDLUM ORDER # 884867

CATALOG # 48-1609, 47-1539, 47-1538 MODEL & SERIAL # M12 #51990, M44-9 # PR054431, M44-40 # PR054432

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

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THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM #5
REQUIREMENT II

Bill Duckaber

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

## C. Ludlum Model 2929 Dual Channel Scaler

# CERTIFICATE OF CALIBRATION

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. LUDLUM MEAS. INC. Model 2929 Serial No. 61551
Mfg. LUDLUM MEAS. INC. Det. Model 43-10-1 Serial No. PR053136
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1 YR. METERFACE
Check mark (✓) applies to applicable instr. and/or detector IAW mfg. spec, s. ☑ New Instrument
☐ Det. (Alpha) Bkgnd ____ cpm ☑ Det. Oper. V 750 V at Alpha - 175 mV B-6 - 4mV to 50mV MV
Temp. 76 Humidity 50 % ☐ F/S Resp. ck ☐ Zero Reset ck. ☑ Audio ck. ☐ Meter Zeroed
☐ Bat. ck. (Min. Volt) ____ VDC ☐ Bat. Volt ____ VDC Instrument Volt Set 750 V
☐ Threshold Dial ____ Input Sens. ____ mV. ☐ Input Sens Linearity
☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 2000 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status ____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☑ Requiring Repair

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |

Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1963

☐ Alpha s/n ____ ☐ Beta s/n ____ ☐ Other ____

☑ M-500 s/n 24797 ☐ Oscilloscope s/n ____ ☐ Multimeter s/n ____

Calibrated By: Elaine Wyatt Date 1-30-89

Reviewed By: Bill Hackshee Date 1-31-89

Form 23 — 3/88

DESIGNER AND MANUFACTURER OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

BENCH TEST DATA FOR DETECTOR 43-10-1 S/N PR053136

CUSTOMER: SAIC Order No. BB-4867

Counter 2929 S/N 161551 Distance-Source to Detector SURFACE

Count Time 1 MINUTE Counter Input Sensitivity ALPHA · 175mV B-G - 4mV to 50mV

Other

| High Volt | Background ALPHA | Background B-G | Isotope Sr-90 Size 130 dpm ALPHA | Isotope Sr-90 Size 130 dpm B-G | Isotope Th230 Size 140 dpm ALPHA | Isotope Th230 Size 140 dpm B-G | Isotope Size ALPHA | Isotope Size B-G |
|---|---|---|---|---|---|---|---|---|
| 700v | 0 | 64 | 0 | 126 | 34 | 76 | | |
| 725v | 0 | 66 | 0 | 127 | 50 | 67 | | |
| 750v | 0 | 68 | 0 | 140 | 69 | 69 | | |
| 775v | 0 | 78 | 1 | 132 | 65 | 69 | | |
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Date 1-30-89 Signature Elaine Wyatt

Form 4

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466882 UD
POST OFFICE BOX 810
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

This Certifies that Ludlum Model 2 64 Serial No. 53343
has been functionally checked.

Date 1-30-89 Order No. 88-4867

Final Check by Elaine Wyatt

Form 24

DESIGNERS AND MANUFACTURERS
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
801 OAK STREET
SWEETWATER, TEXAS, U.S.A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890125-65 LUDLUM ORDER # 884867

CATALOG # 48-1245, 48-1642 MODEL & SERIAL # m2929 # 61551, m264 # 53343
m43-10-1 # 55136

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

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THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM # 12, # 13
REQUIREMENT II

Bill [illegible]

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

## D. Eberline ESP-1

TMA
Thermo Analytical Inc.

TMA/Eberline
5635 Jefferson Street NE
Post Office Box 3874
Albuquerque, NM 87190-3874
(505) 345-9931

# HP-260
# CALIBRATION DATA SHEET

Job #76-76

HP-260 SN: 701303 Property of: SAIC

Readout Inst.: ESPI SN: 1620 Cal. Exp. Date: 10-14-89

High Voltage set at 900 volts

Beta Source SN: SRY-90 52938 Activity: 15,867 DPM mRad/hr: 1.492

Date of Calibration: 3-23-89

Beta Efficiency:

Geometry: SH-4 (with planchet)

5 Min. Ct: 13,000 CPM: 2600.00

5 Min. BKG: 217 CPM: 43.4

Net CPM: 2556.6

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 16.1\ \%$$ 15% ± 2%

1 mRad/hr: 1714 CPM

(Direct On TC-99)
TC-99 SN # C-6094
5 Min. Ct. 15,900
CPM 3180

Date of Calibration: 4-19-89 Expiration Date: 10-19-89

Calibrated by: KENNETH MURPHY (Print Name) Kenneth Murphy (Signature)

Reviewed by: J. B. Date: 4-21-89

TMA
Thermo Analytical Inc

TMA/Eberline
5635 Jefferson Street NE
Post Office Box 3874
Albuquerque, NM 87190-3874
(505) 345-9931

Job #76-76

# ESP-1
# CALIBRATION DATA SHEET

ESP-1 SN: 1620 Property of: SAIC

Location: SAIC/REECo RAMATROL

**High Voltage Check:**

Electrostatic Voltmeter SN: 11166 Cal. Exp. Date: 8-5-89

| ESV | Pre-Cal | Post-Cal | Tolerance |
|---|---|---|---|
| 600V | 610 | 606 | 600±30V |
| 1000V | 1030 | 1000 | 1000±50V |
| 1400V | 1420 | 1400 | 1400±70V |

H.V. set at: 900 volts

**Input Sensitivity Check:**

MP-1 SN: 526 Cal. Exp. Date: 5-21-89

| | Pre-Cal | Post-Cal | |
|---|---|---|---|
| >12mV | | 12 | 12mV±0.5mV |
| <12mV | ✓ (10) | | |

**Scaler**

| MP-1 | ESP-1 | Tolerance |
|---|---|---|
| 1000 CPM | 999 CPM | 1000±5 CPM |
| 10000 CPM | 10,000 CPM | 10000±50 CPM |
| 100K CPM | 100,000 CPM | 100K±500 CPM |

Date of Calibration: 4-19-89 Expiration Date: 10-19-89

Calibrated by: KENNETH MURPHY (Print Name) Kenneth Murphy (Signature)

Reviewed by: 7 H Date: 4-21-89

EA4.26
Rev: 1
Date: 17 April 89

EA4.26-160

TMA
Thermo Analytical Inc

TMA/Eberline
5635 Jefferson Street NE
Post Office Box 3874
Albuquerque, NM 87190-3874
(505) 345-9931

Job #76-76

# HP-210
# CALIBRATION DATA SHEET

HP-210 SN: 704260 Property of: SAIC

Readout Inst.: ESP-1 SN: 1620 Cal. Exp. Date: 10-19-89

High Voltage set at 900 volts

Beta Source SN: SRY-90 52938 Activity: 15,867 DPM mRad/hr: 1.492

Date of Calibration: 3-23-89

Beta Efficiency:

Geometry: SH-4 (with planchet)

5 Min. Ct: 14,800 CPM: 2960.0

5 Min. BKG: 206 CPM: 41.2

Net CPM: 2918.8

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 18.4\ \%$$

(Direct on TC-99)
TC-99 SN#C-6094
5 min. ct. 17,600
CPM. 3520

1 mRad/hr = 1956 CPM

Date of Calibration: 4-19-89 Expiration Date: 10-19-89

Calibrated by: KENNETH MURPHY (Print Name) Kenneth Murphy (Signature)

Reviewed by: 7D Date: 4-21-89

Thermo Analytical Inc.

TMA/Eberline
5635 Jefferson Street NE
Post Office Box 3874
Albuquerque, NM 87190-3874
(505) 345-9931

Job # 76-55

# HP-260
# CALIBRATION DATA SHEET

HP-260 SN: 701304 Property of: Reynolds Electric

Readout Inst.: ESP-1 SN: 1859 Cal. Exp. Date: 4/21/89

High Voltage set at 900 volts

Beta Source SN: Sr-Y-90 S2935 Activity: 16,464 DPM mRad/hr: 1.548

Date of Calibration: 8/1/88

Beta Efficiency:

Geometry: SH-4 (with planchet)

5 Min. Ct: 14,700 CPM: 2940

5 Min. BKG: 251 CPM: 50.2

Net CPM: 2889.8

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 17.6\ \%$$

(Direct on Tc-99)
Tc-99 SN: 4302

1 mRad/hr: 1867 CPM

5 Min. Ct. 10900
CPM 2180

Date of Calibration: 10-25-88 Expiration Date: 4-25-89

Calibrated by: Roy Tucker (Print Name) Roy Tucker (Signature)

Reviewed by: [illegible] Date: 10-25-88

EA4.12
Rev: 1
Date: 25 Jan 88

Thermo Analytical Inc.
TMA/Eberline
5635 Jefferson Street NE
Post Office Box 3874
Albuquerque, NM 87190-3874
(505) 345-9931

Job # 76-55

# HP-210
# CALIBRATION DATA SHEET

HP-210 SN: 704260 Property of: Reynolds Electric

Readout Inst.: ESP-1 SN: 1859 Cal. Exp. Date: 4/21/89

High Voltage set at 900 volts

Beta Source SN: Sr-Y-90 S2935 Activity: 16,464 DPM mRad/hr: 1.548

Date of Calibration: 8/1/88

Beta Efficiency:

Geometry: SH-4 (with planchet)

5 Min. Ct: 15,800 CPM: 3160

5 Min. BKG: 204 CPM: 40.8

Net CPM: 3119.2

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 19.0\ \%$$

Tc-99 SN: 4302
(Direct on Tc-99)

1 mRad/hr = 2015 CPM

5 Min. Ct. 10800
CPM 2160

Date of Calibration: 10-25-88 Expiration Date: 4-25-89

Calibrated by: Roy Tucker (Print Name) Roy Tucker (Signature)

Reviewed by: [illegible] Date: 10-25-88

EA4.11
Rev: 1
Date: 25 Jan 88

Thermo Analytical Inc.

TMA/Eberline
5635 Jefferson Street NE
Post Office Box 3874
Albuquerque, NM 87190-3874
(505) 345-9931

Job #76-55

# ESP-1
# CALIBRATION DATA SHEET

ESP-1 SN: 1859 Property of: Reynolds Electric

Location: Las Vegas, Nevada

**High Voltage Check:**

Electrostatic Voltmeter SN: 11166 Cal. Exp. Date: 8/5/89

| ESV | Pre-Cal | Post-Cal | Tolerance |
|---|---|---|---|
| 600V | 620 | 600 | 600±30V |
| 1000V | 1030 | 1000 | 1000±50V |
| 1400V | 1430 | 1400 | 1400±70V |

H.V. set at: 900 volts

**Input Sensitivity Check:**

MP-1 SN: 526 Cal. Exp. Date: 11/25/88

| | Pre-Cal | Post-Cal | |
|---|---|---|---|
| >10mV | ✓ | 10 | 10mV±0.5mV |
| <10mV | | | |

**Scaler**

| MP-1 | ESP-1 | Tolerance |
|---|---|---|
| 1000 CPM | 1000 CPM | 1000±5 CPM |
| 10000 CPM | 10000 CPM | 10000±50 CPM |
| 100K CPM | 100000 CPM | 100K±500 CPM |

Date of Calibration: 10-25-88 Expiration Date: 4-25-89

Calibrated by: Roy Tucker (Print Name) Roy Tucker (Signature)

Reviewed by: [illegible] Date: 10-25-88

EA4.26
Rev: 0
Date: 27 March 86

## II. Radiation Detection Instrument (Alpha only)

# A. Ludlum Model 65

**CERTIFICATE OF CALIBRATION**

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 65 Serial No. 60879
Mfg. ____ Det. Model ____ Serial No. ____
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1 yr METERFACE 326
Check mark ( ) applies to applicable instr. and/or detector IAW mfg. spec, s. ☑ New Instrument
☑ Det. (Alpha) Bkgnd 1 cpm ☐ Det. Oper. V 2000 V at 3 MV
Temp 77 Humidity 43 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 7.1 VDC ☐ Bat. Volt ____ VDC Instrument Volt Set 2000 V
☐ Threshold Dial ____ Input Sens. 3 mV. ☐ Input Sens Linearity
☑ HV Readout (2 points) Ref./Inst. 2000 / 2000 V Ref./Inst. 2510 / 2500 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status ____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS: Hutton Butane Fuel Flush/Flow Rate 50/5 cc/min

Check Source #208, TH-230 approx. 1100 cpm reads 280 cpm in the x1 range, 2000 V.
Check Source #213, Tc-99 approx. 1100 cpm reads 300 cpm in the x1 range, 2200 V

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 1000 | 250K CPM | 250 | |
| x | | | |
| x 100 | 40 K CPM | 400 | |
| x " | 25 K CPM | 250 | |
| x " | 10 K CPM | 100 | |
| x | | | |
| x 10 | 2.5K CPM | 250 | |
| x | | | |
| x 1 | 250 CPM | 250 | |
| x | | | |
| x | | | |

ALL Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1068

☑ Alpha s/n 6745, 6744, 6743, 6742 ☐ Beta s/n ____ ☐ Other ____

☑ M-500 s/n 24789 ☑ Oscilloscope s/n ~~04499~~ CRS ☑ Multimeter s/n A35790

Calibrated By: Eugene Perry Dunlap Date 1-30-89

Reviewed By: [signature] Date 1-31-89

Form 22 — 3/88

DESIGNER AND MANUFACTURER OF
*Scientific and Industrial Instruments*

**LUDLUM MEASUREMENTS, INC.**
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

**BENCH TEST DATA FOR DETECTOR** 65 **S/N** 60679

**CUSTOMER:** SAIC **Order No.** 88-4867

**Counter** M65 **S/N** 60679 **Distance-Source to Detector** SURFACE

**Count Time** _____ **Counter Input Sensitivity** ~~4.5mV~~ 3mV ERS

**Other** Flow - 5cc/min Flush - 50cc/min.

| High Volt | Background | Isotope Pu-239 Size 65,200 cpm | Isotope Pu-239 Size 247,000 cpm | Isotope Size _____ |
|---|---|---|---|---|
| 2000 | ≈ 1 cpm | x1000<br>360<br>#1 W/ATTENUATOR | x1000<br>140<br>#1 W/ATTENUATOR | |
| | | | | |
| 2000 | ≈ 1 cpm | SIZE: 43710 cpm<br>x100<br>220<br>#2 W/ATTENUATOR | SIZE: 12,500 cpm<br>x100<br>60<br>#3 NO ATTENUATOR | |
| 2000 | ≈ 1 cpm | SIZE: 4064 cpm<br>x10<br>400<br>#3 W/ATTENUATOR | SIZE: 4352 cpm<br>x10<br>220<br>#3 W/ATTENUATOR | SIZE: 3072 cpm<br>x10<br>150<br>#3 W/ATTENUATOR |
| 2000 | ≈ 1 cpm | SIZE: 1011 cpm<br>460<br>#4 W/ATTENUATOR | SIZE: 356 cpm<br>180<br>#4 W/ATTENUATOR | |
| | | ALPHA SOURCES | | |
| | | #1<br>S/N 4745 1,060,000 cpm<br>#2<br>S/N 4744 186,000 cpm | #3<br>S/N 4743 12,800 cpm<br>#4<br>S/N 4742 1620 cpm | |

**Date** 1-30-89 **Signature** Eugene Ray Simcak

Form 4

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466532 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890625-65 LUDLUM ORDER # 4867

CATALOG # 48-1312 MODEL & SERIAL # M65 # 60679

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM 6
REQUIREMENT

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 – 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

BENCH TEST DATA FOR DETECTOR 65 S/N 60679

CUSTOMER: SAIC Order No. 88-4867

Counter M-65 S/N 60679 Distance-Source to Detector CONTACT

Count Time CPM Counter Input Sensitivity 3mV

Other

| High Volt | Background | Isotope TH-230 #208 Size 1100dpm | Isotope C-14 Size .165μC | Isotope Tc-99 #213 Size 100dpm |
|---|---|---|---|---|
| | – | | | |
| 1800 | – | 180 | | |
| 1900 | – | 200 | | |
| 2000 | 1 | 280 | | |
| 2100 | 120 | 350 | 800 | |
| 2200 | 240 | 500 | 20000 | 300 |
| 2300 | 320 | 800 | 40000 | 700 |
| 2400 | 460 | 950 | 43000 | 800 |
| | | | | |
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| | | | | |
| | | | | |

Date 1-30-89 Signature Eugene Roy Lemoll

Form 4

# CERTIFICATE OF CALIBRATION

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

CUSTOMER Reynolds Elec & Eng Co. ORDER NO. 145423
Mfg. Ludlum Model 65 Serial No. 48432
Mfg. — Det. Model — Serial No. —
Cal. Date 1-24-89 Cal. Due Date 1-24-90 Cal. Interval 1yr METERFACE 326
Check mark ( ✓ ) applies to applicable instr. and/or detector IAW mfg. spec, s. ☐ New Instrument
☑ Det. (Alpha) Bkgnd 2 cpm ☑ Det. Oper. V 1900 V at 4 MV
Temp 78 Humidity 42 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 7.1 VDC ☑ Bat. Volt 9 VDC Instrument Volt Set 1900 V
☐ Threshold Dial ____ Input Sens 4 mV. ☐ Input Sens Linearity
☐ HV Readout (2 points) Ref./Inst 500 / 500 V Ref./Inst 2000 / 2000 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status ____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☑ Requiring Repair

COMMENTS: Check source - S.N. 1990 reads 2800 cpm. at 1900v See p.2

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| X 1000 | 400 Kcpm | 400 | N/A |
| X " | 100 " | 100 | |
| X 100 | 40 " | 400 | |
| X " | 25 " | 250 | |
| X " | 10 " | 100 | |
| X 10 | 4 " | 400 | |
| X " | 2.5 " | 250 | |
| X " | 1 " | 100 | |
| X 1 | 400 cpm | 400 | |
| X " | 100 | 100 | |
| X | | | |

All Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1963

☑ Alpha s/n 594-1 set, 53738 ☑ Beta s/n 53740, 635/23 ☐ Other ____

☑ M-500 s/n 54680 ☑ Oscilloscope s/n 04587 ☑ Multimeter s/n A33097

Calibrated By: Paul Dalton Date 1-24-89

Reviewed By: Billy J. Bentley Date 1-24-89

Form 22 — 3/88

2 of 2

# CERTIFICATE OF CALIBRATION

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U.S.A. PH. 915-235-5494

CUSTOMER Reynolds Elec. & Eng. Co. ORDER NO. 145423
Mfg. Ludlum Model 65 Serial No. 48432
Mfg. — Det. Model — Serial No. —
Cal. Date 1-24-89 Cal. Due Date 1-24-90 Cal. Interval 1yr. METERFACE 326
Check mark ( ✓ ) applies to applicable instr. and/or detector IAW mfg. spec, s. ☐ New Instrument
☑ Det. (Alpha) Bkgnd 2 cpm ☑ Det. Oper. V 1900 V at 4 MV
Temp. 78 Humidity 42 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 7.1 VDC ☑ Bat. Volt 9 VDC Instrument Volt Set 1900 V
☐ Threshold Dial ____ Input Sens 4 mV. ☐ Input Sens Linearity
☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2000 / 2000 V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status ____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☑ Requiring Repair

COMMENTS: Check source reads 2800 cpm - at 1900v See p. 1
" " SN - 1990

Instrument meter readings were taken after pulser cal.

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE Pu-239 CAL. POINT S94-1 | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| X 1000 | 675,000 cpm | 370 | NA |
| X | | | |
| X 100 | 64,200 cpm | 322 | |
| X " | 43,710 " | 220 | |
| X " | 12,800 " | 65 | |
| X | | | |
| X 10 | 8064 cpm | 420 | |
| X " | 4352 " | 220 | |
| X " | 3072 " | 155 | |
| X | | | |
| X 1 | 535 cpm | 275 | |

All Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1963

☑ Alpha s/n S94-1 set, S3738 ☑ Beta s/n S3740, 635/83 ☐ Other ____

☑ M-500 s/n 54680 ☑ Oscilloscope s/n 04587 ☑ Multimeter s/n 433097

Calibrated By: Paul Dalton Date 1-24-89

Reviewed By: Billy J Beste Date 1-24-89

Form 22 — 3/88

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial*
INSTRUMENTS

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 TELEX No. 698532 UD
POST OFFICE BOX 810
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

BENCH TEST DATA FOR DETECTOR 65 S/N 48432

CUSTOMER: Reynolds Elec. + Eng. Co. Order No. 145423

Counter 65 S/N 48432 Distance-Source to Detector Surface

Count Time cpm Counter Input Sensitivity 4mv

Other

| High Volt | Background | Isotope Th-230 Size 2157 cpm | Isotope C-14 Size .165 μCi | Isotope Tc-99 Size 2481 cpm |
|---|---|---|---|---|
| 1800 | 0 | 1000 | 0 | 0 |
| 1900 | 2 | 1100 | 200 | 0 |
| 2000 | 16 | 1150 | 8000 PD ~~4000~~ | 150 |
| 2100 | 48 | 1150 | 30000 | 700 |
| 2200 | 160 | 1500 | 44,000 | 1200 |
| 2300 | 220 | 1500 | 55,000 | 1300 |
| 2400 | 300 | 1600 | 60,000 | 1500 |
| 2500 | 300 | 1600 | 80,000 | 1500 |
| | | | | |
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| | | | | |

Date 1-24-89 Signature Paul Dalton

Form 4

LUDLUM MEASUREMENTS, INC.

OCT 11 1989

WORK ORDER No. 145423

Customer Name Reynolds Elec & Eng Co. Condition Received good

Address PO Box 98521 Las Vegas, NV 89193-8521

Special Instructions ☐ YES ☐ Call customer with Est. ☑ Other Repair / 1 yr cal

1. Mod. No. 65 S/N 48432 4. Mod. No. ____ S/N ____ 7. Mod. No. ____ S/N ____

2. Mod. No. ____ S/N ____ 5. Mod. No. ____ S/N ____ 8. Mod. No. ____ S/N ____

3. Mod. No. ____ S/N ____ 6. Mod. No. ____ S/N ____ 9. Mod. No. ____ S/N ____

| ITEM | PART NO. | DESCRIPTION | AMOUNT | PRICE/EA. | COST |
|---|---|---|---|---|---|
| | | | | | |
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| | | | | | |
| | | | | | |
| | | | | | |
| | | Total Parts Cost | | | |

REMARKS: War. Repair

Number Calibrated ____ No. of Probes ____

| | | |
|---|---|---|
| Labor | | |
| Shipping Charges | | |
| Total Charges | | |

Signed Paul Dalton Date 1-24-89

☐ Q/C Reviewed ☐ Customer Notified ☐ Special Instructions Completed

Q/C Released Bobby J Benford Date 1-24-89

Form 10

# III. Radiation Detection Instruments (Dose Rate)

## A. Ludlum Model 19

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

# CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 28-4867
Mfg. Ludlum Model 19 Serial No. 62590
Mfg. _____ Det. Model _____ Serial No. _____
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1 yr METERFACE X 1
Check mark (✓) applies to applicable instr. and/or detector IAW mfg. spec. s. ☑ New Instrument
☐ Det. (Alpha) Bkgnd _____ cpm ☐ Det. Oper. V _____ V at _____ MV
Temp. 75° Humidity 50 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 2.2 VDC ☐ Bat. Volt _____ VDC Instrument Volt Set 7.6 V
☐ Threshold Dial _____ Input Sens 41 mV. ☐ Input Sens Linearity
☐ HV Readout (2 points) Ref./Inst. _____ / _____ V Ref./Inst. _____ / _____ V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status _____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 5000 | 2 mR/hr ≡ 370 Kcpm | 20.5 | |
| x 500 | 37 Kcpm | 20 | |
| x 250 | 37 " | 20 | |
| x 50 | 3.7 " | 20 | |
| x 25 | 3.7 " | 20 | |
| x " | 2.77 " | 15 | |
| x " | 1.81 " | 10 | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |

x500, x250, x50, x25 Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL- STD-45662A and ANSI N323-1978.

☑ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1963

☐ Alpha s/n _____ ☐ Beta s/n _____ ☐ Other _____

☑ M-500 s/n 18425 ☑ Oscilloscope s/n _____ ☑ Multimeter s/n 32733

Calibrated By: Michael Gaston Date 1-30-89

Reviewed By: [illegible] Date 1-31-89

Form 22 — 3/88

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U.S.A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-880125-65 LUDLUM ORDER # 88-4867

CATALOG # 48-1615 MODEL & SERIAL # m19 # 62596

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM # 14
REQUIREMENT II

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

## CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 19 Serial No. 62550
Mfg. ____ Det. Model ____ Serial No. ____
Cal. Date 1-30-89 Cal. Due Date 1-30-90 Cal. Interval 1yr METERFACE x16
Check mark ( ✓ ) applies to applicable instr. and/or detector IAW mfg. spec, s. ☐ New Instrument
☐ Det. (Alpha) Bkgnd ____ cpm ☐ Det. Oper. V ____ V at ____ MV
Temp. 75° Humidity 50 % ☑ F/S Resp. ck ☑ Zero Reset ck. ☑ Audio ck. ☑ Meter Zeroed
☑ Bat. ck. (Min. Volt) 2.2 VDC ☐ Bat. Volt ____ VDC Instrument Volt Set 900 V
☐ Threshold Dial ____ Input Sens. 4.3 mV. ☐ Input Sens Linearity
☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status ____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| x 5000 | 2mR/hr ≅ 390Kcpm | 20 | |
| x 500 | 39 Kcpm | 20 | |
| x 250 | 39 | 20 | |
| x 50 | 39 " | 20 | |
| x 25 | 39 " | 20 | |
| x " | 2.93 " | 15 | |
| x " | 1.93 " | 10 | |
| x | | | |
| x | | | |
| x | | | |
| x | | | |

x500, x250, x50, x25 Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL- STD-45662A and ANSI N323-1978.

☑ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304 State of Texas Calibration License No. LO-1988

☐ Alpha s/n ____ ☐ Beta s/n ____ ☐ Other ____
☑ M-500 s/n 18475 ☐ Oscilloscope s/n ____ ☑ Multimeter s/n 32733
Calibrated By: Michael Gaston Date 1-30-89
Reviewed By: [illegible] Date 1-31-89

Form 22 — 3/88

DESIGNERS AND MANUFACTURERS
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-890125-65 LUDLUM ORDER # 884867

CATALOG # 48-1615 MODEL & SERIAL # m19 # 62550

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM # 14
REQUIREMENT II

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

# IV. Radiation Sources

## A. Alpha

**THE SOURCE, Inc.**
Radiation standards and check sources
2889 Industrial RD. Santa Fe, NM 87501
(505)473-9538

# Certificate of Calibration
(Alpha Sources)

The Thorium230 alpha source was measured in a hemispherical 2pi windowless proportional counter using P-10 as counting gas. The alpha emissions from the surface of the source were measured at its plateau voltage to determine its 2pi cpm rate. Corrections were applied for background, coincidence loss and backscatter factors when applicable. The source is referenced to NIST(formerly NBS).

70 cpm +/- 7 cpm 2pi

140 dpm +/- 14 dpm

6.22E-05 microcurie

01-10-89 date of measurement

Michael A. Ortiz calibrated by

Charles L. Gonzales approved by

89 TH4700205 source number

The uncertainty of the measurement at the 99% confidence interval is 10 percent.

SOURCE

Radiation standards and check sources
2889 Industrial Rd. Santa Fe, NM 87501
(505) 473-9538

# Certificate of Calibration

(Alpha Sources)

The 230 Thorium alpha source was measured in a hemispherical 2π windowless proportional counter using P-10 as counting gas. The alpha emissions from the surface of the source were measured at its plateau voltage to determine its 2π cpm rate. Corrections were applied for background, coincidence loss and backscatter factors when applicable. Source is referenced to NBS standard.

| | |
|---|---|
| 7380 2pi | cpm |
| 14,540dpm | dpm |
| 0.00655 | microcurie |
| 05-25-88 | date of measurement |
| Michael A. Ortiz | analyst |
| 88TH2201990 S-Th-22 | source number |

The uncertainty of the measurement at the 99% confidence interval is 5%.

THE SOURCE
...uation standards and check sources
2869 Industrial Rd. Santa Fe, NM 87501
(505) 473-9538

Rcv'D
12-3-87

# Certificate of Calibration

(Alpha Sources)

The 230 Thorium alpha source was measured in a hemispherical 2π windowless proportional counter using P-10 as counting gas. The alpha emissions from the surface of the source were measured at its plateau voltage to determine its 2π cpm rate. Corrections were applied for background, coincidence loss and backscatter factors when applicable. Source is referenced to NBS standard.

| | |
|---|---|
| 184 2pi | cpm |
| 357 | dpm |
| 0.000161 | microcurie |
| 12-01-87 | date of measurement |
| Michael A. Ortiz | analyst |
| 87TH2200849 S-Th-22 | source number |

**The uncertainty of the measurement at the 95% confidence interval is 10%.**

## B. Beta

**THE SOURCE, Inc.**
Radiation standards and check sources
2889 Industrial RD. Santa Fe, NM 87501
(505)473-9538

# Certificate of Calibration
(Beta Sources)

The Strontium,Yttrium90 beta source was measured in a hemispherical 2pi windowless proportional counter using P-10 as counting gas. The beta emissions from the surface of the source were measured at its plateau voltage to determine its 2pi cpm rate. Corrections were applied for background, coincidence loss and backscatter factors when applicable. The source is referenced to NIST(formerly NBS).

90 cpm +/- 9 cpm 2pi

130 dpm +/- 13 dpm

5.76E-05 microcurie

01-10-89 date of measurement

Michael A. Ortiz calibrated by

Charles L. Gonzales approved by

89SR4700206 source number

The uncertainty of the measurement at the 99% confidence interval is 10 percent.

Amersham Buchler GmbH & Co KG

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Büros in Frankfurt und Düsseldorf
Vertretungen in Berlin (West) und München

Amersham

Amersham Buchler GmbH & Co KG Postfach 11 20 D-3300 Braunschweig

Amersham International plc

White Lion Road Amersham

Buckinghamshire England HP7 9LL

**Certificate no.** 218942-6

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.

To determine the emission rate, the absorption of the capsule has to be taken into account.

The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 505 |
| Activity | 66.1 kBq (1.79 µCi) Mercury-203 |
| Date of measurement of activity | 25 March 1988 |
| Overall uncertainty* | ± 5 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |
| Integrity ISO/BSI/DIN/ANSI Classification | C.34313 |
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

Amersham Buchler



Amtsgericht Braunschweig HRA 8621

Deutsche Bank AG Braunschweig BLZ 270 700 30

# control

## Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanediol) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS.5288/App. D.3·1, except that for some sources, the 100mm³ free volume requirement is not met).

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005μCi.
(This test conforms to BS.5288/App. D. 2·4)

**Helium mass spectrograph test H**
Limit: leak rate of $10^{-6}$ standard cm³/sec.
(This test used conforms to either BS.5288/App. D.3·4 or D.3·5, but our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting.
(DWIGHT, D. J. Radiochemical Centre Report R.176.)
The limit corresponds to about $5 \times 10^{-11}$Ci per 24 hours.
(This test conforms to BS.5288/App. D. 2·6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations.
(IAEA Safety Series No. 6, 1967/1973 revised edition†).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are:
impact test
percussion test
bending test (only for long, slender sources)
heat test.
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

†1973 regulations not yet universally adopted

## Source working life

The *'recommended working life'* is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
Adverse environments could affect the appearance and integrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the "recommended working life" the source should be replaced.

## ISO Classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned".

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

### Table 1. Classification of sealed source performance standards

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 170Mpa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibration | No test | 30mm 25Hz to 500Hz at 5gn peak amplitude | 30mm 25Hz to 50Hz at 5gn peak amplitude and 50Hz to 500Hz at 0·635mm amplitude peak to peak and 50Hz to 500Hz at 10gn | 50mm 25Hz to 50Hz at 1·5mm amplitude peak to peak and 50Hz to 3000Hz at 30gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO.2919 and BS.5288. A further class 6 can be used where a special test procedure has been adopted.
3. Impact test
   The source, positioned on a steel anvil, is struck by a steel hammer of the required weight, the hammer has a flat striking surface, 25mm diam. with the edges rounded.
2. External pressure
   100kPa = 1 atmosphere (approx.)
4. Puncture test
   The source, positioned on a hardened steel anvil, is struck by a hardened pin, 6mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

### Table 2. Sealed source performance requirements for typical uses

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (excluding gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 6 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or daily transportable) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source applications (including reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 30μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 3 | 4 |
| | Source in device | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Beta chromatography | 2 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 3 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Interstitial and intracavitary applications* | 5 | 3 | 2 | 1 | 1 |
| | Surface applications | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deformation in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:

1. consequences of loss of activity,
2. quantity of active material contained in the source,
3. radiotoxicity,
4. chemical and physical form of the material and the geometrical shape,
5. environment in which it is to be used,
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our sources designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

Acknowledgement: Tables from BS.5288:1976 are reproduced by permission of BSI, 2 Park Street, London W1A 2BS from whom complete copies can be obtained.

## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

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Amersham

Amersham International plc
White Lion Road Amersham
Buckinghamshire England HP7 9LL

**Certificate no.** 218942-7

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.
To determine the emission rate, the absorption of the capsule has to be taken into account.
The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 506 |
| Activity | 38.26 kBq (1.034 µCi) Sodium-22 |
| Date of measurement of activity | 25 March 1988 |
| Overall uncertainty* | ± 3 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |
| Integrity ISO/BSI/DIN/ANSI Classification | C.34313 |
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

Traceability: The activity of the source above-mentioned has been measured against a reference source, calibrated by the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig.

Amersham Buchler



Sitz Braunschweig Registergericht Braunschweig, HRA 8621

Deutsche Bank AG Braunschweig, BLZ 270 700 30.

# control

## Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanol/oil) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS.5288/App. D.3·1, except that for some sources, the 100mm³ free volume requirement is not met).

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005μCi.
(This test conforms to BS.5288/App. D. 2·4)

**Helium mass spectrograph test H**
Limit: leak rate of $10^{-8}$ standard cm³/sec.
(This test used conforms to either BS.5288/App. D.3·4 or D.3·5, but our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting. (DWIGHT, D. J. Radiochemical Centre Report R.176.)
The limit corresponds to about $5 \times 10^{-11}$Ci per 24 hours.
(This test conforms to BS.5288/App. D. 2·6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations.
(IAEA Safety Series No. 6. 1967/1973 revised edition†).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are:
impact test
percussion test
bending test (only for long, slender sources)
heat test.
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

†1973 regulations not yet universally adopted.

## Source working life

The *'recommended working life'* is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
Adverse environments could affect the appearance and integrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the "recommended working life" the source should be replaced.

## ISO Classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned".

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

### Table 1. Classification of sealed source performance standards

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 170MPa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibrations | No test | 30mm 25Hz to 500Hz at 5gn peak amplitude | 30mm 25Hz to 50Hz at 5gn peak amplitude and 50Hz to 500Hz at 0·635mm amplitude peak to peak and 50Hz to 500Hz at 10gn | 50mm 25Hz to 50Hz at 1·5mm amplitude peak to peak and 50Hz to 3000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO 2919 and BS.5288. A further class X can be used where a special test procedure has been adopted.
2. External pressure
   100kPa = 1 atmosphere (approx.)
3. Impact test
   The source, positioned on a steel anvil, is struck by a steel hammer of the required weight, the hammer has a flat striking surface, 25mm diam. with the edges rounded.
4. Puncture test
   The source, positioned on a hardened steel anvil, is struck by a hardened pin, 6mm long, 3mm diam. with hemispherical end, fired by a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

### Table 2. Sealed source performance requirements for typical uses

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (including gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 6 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or daily transported) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source application (including reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 20μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 2 | 4 |
| | Source in device | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 3 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 2 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Interstitial and intracavitary applicators* | 5 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deformation in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:
1. consequences of loss of activity,
2. quantity of active material contained in the source,
3. radiotoxicity,
4. chemical and physical form of the material and the geometrical shape,
5. environment in which it is to be used,
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our source designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

Acknowledgement: Tables from BS.5288:1976 are reproduced by permission of BSI, 2 Park Street, London W1A 2BS from whom complete copies can be obtained.

## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

[redacted] Buchler GmbH & [redacted] KG

[redacted]weg 1 D-3300 Braunschweig
Telefon (0 53 07) 8 08 - 0
Telex 9 52 830 ambu d

Büros in Frankfurt und Düsseldorf
Vertretungen in Berlin (West) und München

Amersham

Amersham Buchler GmbH & Co KG Postfach 11 20 D-3300 Braunschweig

Amersham International plc
White Lion Road Amersham
Buckinghamshire England HP7 9LL

**Certificate no.** 218942-8

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.
To determine the emission rate, the absorption of the capsule has to be taken into account.
The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 507 |
| Activity | 35.2 kBq (951 nCi) Yttrium-88 |
| Date of measurement of activity | 29 March 1988 |
| Overall uncertainty* | ± 5 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |

Integrity ISO/BSI/DIN/ANSI Classification

| | |
|---|---|
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

Amersham Buchler

87 R1000

Sitz Braunschweig Registergericht Braunschweig HRA 8621

Deutsche Bank AG Braunschweig BLZ 270 700 30

# control

## Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanediol) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS.5288/App. D.3·1, except that for some sources, the 100mm³ free volume requirement is not met.

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005μCi.
(This test conforms to BS.5288/App. D. 2·4)

**Helium mass spectrograph test H**
Limit: leak rate of $10^{-6}$ standard cm³/sec.
(This test used conforms to either BS.5288/App. D.3·4 or D.3·5, but our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting. (DWORT, D. J. Radiochemical Centre Report R.176.)
The limit corresponds to about $5 \times 10^{-11}$Ci per 24 hours.
(This test conforms to BS.5288/App. D. 2·6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations.
(IAEA Safety Series No. 6. 1967/1973 revised edition*).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are:
impact test
percussion test
bending test (only for long, slender sources)
heat test.
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

*1973 regulations not yet universally adopted

## Source working life

The *'recommended working life'* is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
Adverse environments could affect the appearance and integrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the "recommended working life" the source should be replaced.

## ISO Classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"The system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned".

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

**Table 1. Classification of sealed source performance standards**

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmosphere pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 170MPa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibration | No test | 30mm 25Hz to 500Hz at 5gn peak amplitude | 30mm 25Hz to 80Hz at 5gn peak amplitude and 80Hz to 500Hz at 0·635mm amplitude peak to peak and 500Hz to 2000Hz at 10gn | 50mm 25Hz to 80Hz at 1·5mm amplitude peak to peak and 80Hz to 2000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO 2919 and BS.5288. A further class X can be used where a special test procedure has been adopted.
2. External pressure 100kPa = 1 atmosphere (approx.)
3. Impact test
   The source, positioned on a steel anvil, is struck by a steel hammer of the required weight, the hammer has a flat striking surface, 25mm diam. with the edges rounded.
4. Puncture test
   The source, positioned on a hardened steel anvil, is struck by a hardened pin, 5mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

**Table 2. Sealed source performance requirements for typical uses**

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (including gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 6 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or daily transported) | | 4 | 3 | 3 | 3 | 3 |
| Gamma neutron source application (including reactor start-up) | | 4 | 3 | 3 | 3 | 3 |
| Calibration sources, activity greater than 30μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 2 | 4 |
| | Source in device | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 2 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 3 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Interstitial and intracavitary applicators* | 5 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deformation in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:

1. consequences of loss of activity,
2. quantity of active material contained in the source,
3. radiotoxicity,
4. chemical and physical form of the material and the geometrical shape,
5. environment in which it is to be used,
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our source designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

Acknowledgement: Tables from BS.5288:1976 are reproduced by permission of BSI, 2 Park Street, London W1A 2BS from whom complete copies can be obtained.

## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

## D. Mixed Sources

Amersham UK

[redacted]

BRITISH CALIBRATION SERVICE

Approval No 0146

**Description** Product code: QCD.1 Source number: 1410QB

This mixed radionuclide gamma-ray reference source contains the nine radionuclides listed below.

**Measurement and Accuracy** Reference time: 1200 GMT on 1 October 1987

| Parent radionuclide | Gamma-ray energy (MeV) | Gamma-rays per second | Random uncertainty | Systematic uncertainty | Overall uncertainty |
|---|---|---|---|---|---|
| Cadmium-109 | 0.088 | 744 | ± 0.3 % | ± 4.0 % | ± 4.3 % |
| Cobalt-57 | 0.122 | 674 | ± 0.3 % | ± 2.1 % | ± 2.4 % |
| Cerium-139 | 0.166 | 802 | ± 0.4 % | ± 3.8 % | ± 4.2 % |
| Mercury-203 | 0.279 | 2351 | ± 0.2 % | ± 2.3 % | ± 2.5 % |
| Tin-113 | 0.392 | 2404 | ± 0.2 % | ± 4.6 % | ± 4.8 % |
| Strontium-85 | 0.514 | 4539 | ± 0.3 % | ± 2.1 % | ± 2.4 % |
| Caesium-137 | 0.662 | 2807 | ± 0.5 % | ± 2.9 % | ± 3.4 % |
| Yttrium-88 | 0.898 | 7187 | ± 0.2 % | ± 3.8 % | ± 4.0 % |
| Cobalt-60 | 1.173 | 3922 | ± 0.3 % | ± 0.7 % | ± 1.0 % |
| Cobalt-60 | 1.333 | 3927 | ± 0.3 % | ± 0.7 % | ± 1.0 % |
| Yttrium-88 | 1.836 | 7662 | ± 0.2 % | ± 2.8 % | ± 3.0 % |

**Purity** At the reference time the following impurities were also present:

Cadmium-113m less than $6.0 \times 10^{-5}$ microcuries

Cobalt-56 less than $6.6 \times 10^{-6}$ microcuries

Cobalt-58 less than $2.7 \times 10^{-6}$ microcuries

Rubidium-86 less than $6.6 \times 10^{-6}$ microcuries

Zinc-65 less than $1.3 \times 10^{-5}$ microcuries

**Remarks** Further details, including preparation of the source, methods of measurement, decay scheme assumptions, decay tables and definitions of uncertainties, are given in the data sheet accompanying this certificate.

Tests for leakage and for surface contamination have been carried out with satisfactory results.

This product meets the quality assurance requirements of NRC Regulatory Guide 4.15 for achieving explicit NBS traceability as defined in NCRP58 (1985).

**Approved Signatory**

A.G. Tuck



Amersham

This certificate is issued in accordance with the conditions of approval granted by the British Calibration Service which has verified the measurement capability of the laboratory and its traceability to United Kingdom national standards and to the units of mass, amount

## E. Radon Sources

# CERTIFICATE OF CALIBRATION

Product RNC Calibration Radon Standard

Date of Calibration February 28, 1987

Serial No. 102

Active Material $Ra^{226}$

Half-Life Long Term

Form Dry Powder

Source Activity 2,500 pCi or 0.09 kBq ± 4%

Housing Aluminum

Active Deposit on Filter N/A DPM/cm$^2$

Dispensed Activity N/A pCi±

## METHOD OF CALIBRATIION

[x] Source calibrated by Alpha Scintillation methods on a Model RM 1003 Radon Gas Monitor against NBS traceable standards.

[ ] Source assayed by Alpha Spectrometry on a surface barrier detector against NBS traceable standards.

Error Estimated 4%

$$\text{Error} = \sqrt{e_1^2 + e_2^2} + \text{Error of Reference Standard}$$

Where $e_1$ = Precision of Source Count

$e_2$ = Precision of Standard Count

Signature: A. Lebel

Title: Chemical Technologist

PYLON ELECTRONIC DEVELOPMENT company, ltd.

PYLON 147 Colonnade Rd. Ottawa, Ontario Canada K2E 7L9

# LEAK TEST CERTIFICATE

Customer Applied Health Physics P.O. 8612-6546

Source RNC Housing Aluminum

Serial Number 102

Active Material $Ra^{226}$ Gas Phase $Rn^{222}$

THE LEAK TESTS INDICATED BY THE CHECKED BOXES WERE APPLIED TO DETERMINE THE INTEGRITY OF THE SOURCE(S) IN THIS SHIPMENT.

(x) 1. STANDARD WIPE TEST

The source is swabbed over its entire surface with a moistened paper or cotton swab. After being allowed to dry, the swab is counted using a windowless scintillation counter. Activity levels exceeding .00001 microcuries will be cause for rejection.
Measured Activity: none μCi alpha beta gamma

( ) 2. BUBBLE TEST

The source is immersed in ethylene glycol to a depth of 2" in a glass container and a pressure of 10 cm or less applied. A steady stream of bubbles from the window or weld detail will be cause for rejection.

(x) 3. GAS SOURCE TEST (Radioactive Gases)

The source is placed in a sealed chamber and left for a period of approximately 3 days. An air sample is taken and its activity determined by standard α scintillation methods. A count rate exceeding 100 cpm will be cause for rejection.

( ) 4. LEAK TEST NOT APPLICABLE

The active area of this source is uncovered or protected by a very thin coating. Although the deposit is adherent, it is not designed or certified to pass a standard leak test. The inactive portions of the source have been checked using the standard wipe test and found not to exceed .00001 μCi of removable activity at time of shipment.

Signed A. Lebel
Chemical Technologist

Date March 17, 1987

PYLON ELECTRONIC DEVELOPMENT company, ltd.
PYLON 147 Colonnade Rd. Ottawa, Ontario Canada K2E 7L9

# CERTIFICATE OF CALIBRATION

Product 47mm Radon Daughter Standard

Date of Calibration September 26, 1986 Serial No. 121

Active Material $Ra^{226}$

Half-Life Long Term Form Dry; Powder

Source Activity N/A kBq ±

Active Deposit on Filter 4,450 $DPM/cm^2$ Housing Aluminum

Dispensed Activity N/A. pCi±

## METHOD OF CALIBRATIION

[x] Source calibrated by Alpha Scintillation methods on a Model RM 1003 Radon Gas Monitor against NBS traceable standards.

[ ] Source assayed by Alpha Spectrometry on a surface barrier detector against NBS traceable standards.

Error Estimated 4%

$$\text{Error} = \sqrt{e_1^2 + e_2^2} + \text{Error of Reference Standard}$$

Where $e_1$ = Precision of Source Count

$e_2$ = Precision of Standard Count

Signature: A. Lebel

Title: Chemical Technologist

PYLON ELECTRONIC DEVELOPMENT company, ltd.

PYLON 147 Colonnade Rd. Ottawa, Ontario Canada K2E 7J9

# LEAK TEST CERTIFICATE

Customer APPLIED HEALTH PHYSICS P.O. 8612-6546

Source Rn-190-47 Housing Aluminum

Serial Number 121

Active Material $Ra^{226}$ Gas Phase $Rn^{222}$

THE LEAK TESTS INDICATED BY THE CHECKED BOXES WERE APPLIED TO DETERMINE THE INTEGRITY OF THE SOURCE(S) IN THIS SHIPMENT.

(x) 1. STANDARD WIPE TEST

The source is swabbed over its entire surface with a moistened paper or cotton swab. After being allowed to dry, the swab is counted using a windowless scintillation counter. Activity levels exceeding .00001 microcuries will be cause for rejection.
Measured Activity: None. μCi alpha beta gamma

( ) 2. BUBBLE TEST

The source is immersed in ethylene glycol to a depth of 2" in a glass container and a pressure of 10 cm or less applied. A steady stream of bubbles from the window or weld detail will be cause for rejection.

( ) 3. GAS SOURCE TEST (Radioactive Gases)

The source is placed in a sealed chamber and left for a period of approximately 3 days. An air sample is taken and its activity determined by standard α scintillation methods. A count rate exceeding 100 cpm will be cause for rejection.

( ) 4. LEAK TEST NOT APPLICABLE

The active area of this source is uncovered or protected by a very thin coating. Although the deposit is adherent, it is not designed or certified to pass a standard leak test. The inactive portions of the source have been checked using the standard wipe test and found not to exceed .00001 μCi of removable activity at time of shipment.

Signed A. Lebel.
Chemical Technologist

Date March 6, 1987.

PYLON ELECTRONIC DEVELOPMENT company, ltd.
PYLON 147 Colonnade Rd. Ottawa, Ontario Canada K2E 7L9

The Applied HEALTH PHYSICS Inc.
2980 Industrial Blvd. • Box 197 • Bethel Park, Pa. 15102 • Phone 412 • 563-2242

THIS PACKAGE CONFORMS TO THE CONDITIONS AND LIMITATIONS SPECIFIED IN 49CFR173.421 FOR EXCEPTED RADIOACTIVE MATERIAL, LIMITED QUANTITY, N.O.S; UN 2910.

NAME Nathaniel L. Burden Jr.
DATE 4-15-87

## C. Gamma

Gieselweg 1 D-3300 Braunschweig
Telefon (0 53 07) 8 08 - 0
Telex 9 52 830 ambu d

Buros in Frankfurt und Dusseldorf
Vertretungen in Berlin (West) und Munchen

Amersham Buchler GmbH & Co KG Postfach 11 20 D-3300 Braunschweig

Amersham

Amersham Corporation
C/O R.A. Ciszon Customs Broker

9420 West Forster
USA-Chicago Illinois 60656

**Certificate no.** 193261

Date 20 January 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide
To determine the emission rate, the absorption of the capsule has to be taken into account.
The source passed the leakage test

| | |
|---|---|
| Type | ASSOEU (EFRX1031) |
| Source No | AR 716 |
| Activity | 22.46 kBq (607.0 nCi) Europium-152 |
| Date of measurement of activity | 13 January 1988 |
| Overall uncertainty* | ± 4 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |

Integrity ISO/BSI/DIN/ANSI Classification

| | |
|---|---|
| Leakage test and result | L and A |
| Date of leakage test | 20 January 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

Amersham Buchler

Sitz Braunschweig Registergericht Braunschweig HRA 8621
Persönlich haftende Gesellschafterin Amersham Buchler GmbH Sitz Braunschweig
Registergericht Braunschweig HRB 638 Geschäftsführer Dr Walther H Buchler Dr Klaus Leising
Vorsitzender des Aufsichtsrates Wolfgang [illegible]

Deutsche Bank AG Braunschweig BLZ 270 700 30
Konto 0 168 815
Postgiroamt Hannover BLZ 250 100 30 Konto 3133 30-300

## ...ol

### ...esting for leakage and contamination

S... tests for leakage are an essential feature of ... sources production. The methods adopted de... on the design and intended application of the source and also on statutory requirements. Where necessary tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water, the activity removed is measured. Limit: 0.005μCi.
This test conforms to BS 5288/App. D 2.1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water, the activity removed is measured. Limit: 0.05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanediol) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
This test conforms to BS 5288 App. D 3.1 except that for some sources the 100mm³ free volume requirement is not met.

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0.05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0.005μCi.
This test conforms to BS 5288 App. D 2.3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0.005μCi.
This test conforms to BS 5288/App. D 2.4)

**Helium mass spectrograph test H**
L... rate of $10^{-8}$ standard cm³/sec
...sed conforms to either BS 5288/App. D 3.4 or ... our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum, the leakage of radon is measured by liquid scintillation counting. (Dwight D... Radiochemical Centre Report R 176.)
The limit corresponds to about 5 x 10⁻¹¹Ci per 24 hours.
This test conforms to BS 5288/App. D 2.6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations
(IAEA Safety Series No. 6 1967 1973 revised edition*).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are
impact test
percussion test
bending test (only for long, slender sources)
heat test
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

*1973 regulations not yet universally adopted

## Source working life

The '*recommended working life*' is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as: toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, ... formance data, etc.
... environments could affect the appearance ... egrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the 'recommended working life' the source should be replaced.

## ISO ...sification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned."

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

### Table 1. Classification of sealed source performance standards

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 700MPa absolute | 25kPa absolute to 1700kPa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibration | No test | 30min 25Hz to 500Hz at 5gn peak amplitude | 30min 25Hz to 50Hz at 5gn peak amplitude and 50Hz to 500Hz at 0.635mm amplitude peak to peak and 80Hz to 500Hz at 10gn | 90min 25Hz to 80Hz at 1.5mm amplitude peak to peak and 80Hz to 2000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO 2919 and BS 5288. A further class X can be used where a special test procedure has been adopted.
2. External pressure
   100kPa = 1 atmosphere (approx.)
3. Impact test
   The source, positioned on a steel anvil, is struck by a steel hammer of the required weight. The hammer has a flat striking surface, 25mm diam. with the edges rounded.
4. Puncture test
   The source, positioned on a hardened steel anvil, is struck by a hardened pin, 6mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO 2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

### Table 2. Sealed source performance requirements for typical uses

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysers (excluding gas filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | E | 5 | 2 | 4 |
| Portable moisture and density gauges (including hand held or daily transported) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source application (excluding reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 30μCi | | 2 | 2 | 2 | | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 2 | 4 |
| | Source in device | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 2 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 2 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Intracavitary and interstitial applications* | 5 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deformation in use. Manufacturers and users may wish to formulate additional or tailor test procedures.

**If the sealed source has a 'C' classification,**
Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:
1. consequences of loss of activity
2. quantity of active material contained in the source.
3. radiotoxicity.
4. chemical and physical form of the material and the geometrical shape
5. environment in which it is to be used
6. protection afforded to the source or source-device combination

**If the sealed source has an 'E' classification,**
Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our source designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

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## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

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**Certificate no.** 218942-1

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.
To determine the emission rate, the absorption of the capsule has to be taken into account.
The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 500 Ba-133 |
| Activity | 34.22 kBq (924.9 nCi) Barium-133 |
| Date of measurement of activity | 24 March 1988 |
| Overall uncertainty* | ± 4 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |
| Integrity ISO/BSI/DIN/ANSI Classification | C.34313 |
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

Traceability: The activity of the source above-mentioned has been measured against a reference source, calibrated by the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig.

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# ...rity control

## Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005uCi.
(This test conforms to BS 5288/Appl. D.2.1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05uCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanol/oil) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS 5288/Appl. D.3.1; except that for some sources, the 100mm/ free volume requirement is not met).

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05uCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005uCi.
(This test conforms to BS 5288/Appl. D.2.3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005uCi.
(This test conforms to BS 5288/Appl. D. 2·4)

**Helium mass spectrograph test H**
Limit: leak rate of $10^{-8}$ standard cm³/sec.
(This test used conforms to either BS 5288/Appl. D.3-4 or D.3.5, but our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting.
(DWIGHT D. J. Radiochemical Centre Report R.176.)
The limit corresponds to about $5 \times 10^{-11}$Ci per 24 hours.
(This test conforms to BS 5288/Appl. D. 2.6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations.
(IAEA Safety Series No. 6. 1967/1973 revised edition†).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are:
impact test
percussion test
bending test (only for long, slender sources)
heat test.
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

†1973 regulations not yet universally adopted.

## Source working life

The *'recommended working life'* is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
Adverse environments could affect the appearance and integrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the "recommended working life" the source should be replaced.

## ISO Classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned"

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

**Table 1. Classification of sealed source performance standards**

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 1 700kpa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibration | No test | 30mm 25Hz to 500Hz at 5gn peak amplitude | 30mm 25Hz to 50Hz at 5gn peak amplitude and 50Hz to 500Hz at 0.635mm amplitude peak to peak and 50Hz to 500Hz at 10gn | 50mm 25Hz to 50Hz at 1.5mm amplitude peak to peak and 50Hz to 2000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO 2919 and BS 5288. A further class X can be used where a special test procedure has been adopted.

2. External pressure
100kPa = 1 atmosphere (approx.)

3. Impact test
The source, positioned on a steel anvil, is struck by a steel hammer of the required weight, the hammer has a flat striking surface, 25mm diam. with the edges rounded.

4. Puncture test
The source, positioned on a hardened steel anvil, is struck by a hardened pin, 6mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

**Table 2. Sealed source performance requirements for typical uses**

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (including gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 6 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or easily transported) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source application (including reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 30uCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 2 | 4 |
| | Source in device | * | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 2 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 3 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Implanted and intracavitary applicators | 5 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deterioration in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:
1. consequences of loss of activity,
2. quantity of active material contained in the source,
3. radiotoxicity,
4. chemical and physical form of the material and the geometrical shape,
5. environment in which it is to be used,
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our source designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

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## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

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**Certificate no.** 218942-3

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.
To determine the emission rate, the absorption of the capsule has to be taken into account.
The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 502 |
| Activity | 40.53 kBq (1.095 µCi) Cobalt-57 |
| Date of measurement of activity | 3 March 1988 |
| Overall uncertainty* | ± 4 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |
| Integrity ISO/BSI/DIN/ANSI Classification | C.34313 |
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

Traceability: The activity of the source above-mentioned has been measured against a reference source, calibrated by the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig.

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## .ity control

### Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005μCi.
(This test conforms to BS 5288/App. D.2.1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanediol) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS 5288/App. D.3.1 except that for some sources, the 100mm³ free volume requirement is not met).

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005μCi.
(This test conforms to BS 5288/App. D.2.3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005μCi.
(This test conforms to BS 5288/App. D.2.4)

**Helium mass spectrograph test H**
Limit: leak rate of $10^{-8}$ standard cm³/sec.
(This test used conforms to either BS 5288/App. D.3.4 or D.3.5, but our limit is much more stringent).

**Emanation test K**
(scintillation counting test for radon)
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting (DWIGHT D J, Radiochemical Centre Report R.178.)
The limit corresponds to about $5 \times 10^{-4}$Ci per 24 hours.
(This test conforms to BS 5288/App. D.2.6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations.
(IAEA Safety Series No. 6, 1967/1973 revised edition*).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are:
impact test
percussion test
bending test (only for long, slender sources)
heat test.
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

*1973 regulations not yet universally adopted.

## Source working life

The 'recommended working life' is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
Adverse environments could affect the appearance and integrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the "recommended working life" the source should be replaced.

## ISO Classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"The system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned"

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity.
Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

### Table 1. Classification of sealed source performance standards

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 170MPa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibration | No test | 30min 25Hz to 500Hz at 5gn peak amplitude | 30min 25Hz to 50Hz at 5gn peak amplitude and 50Hz to 90Hz at 0·635mm amplitude peak to peak and 90Hz to 500Hz at 10gn | 90min 25Hz to 80Hz at 1·5mm amplitude peak to peak and 80Hz to 2000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO 2919 and BS 5288. A further class X can be used where a special test procedure has been adopted.
2. External pressure
100kPa = 1 atmosphere (approx.)
3. Impact test
The source, positioned on a steel anvil, is struck by a steel hammer of the required weight; the hammer has a flat striking surface, 25mm diam. with the edges rounded.
4. Puncture test
The source, positioned on a hardened steel anvil, is struck by a hardened pin, 6mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

### Table 2. Sealed source performance requirements for typical uses

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (excluding gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 6 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or dolly transported) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source application (excluding reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 30μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 2 | 4 |
| | Source in device | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 2 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 2 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Interstitial and intracavitary applicators* | 6 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deformation in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:
1. consequences of loss of activity,
2. quantity of active material contained in the source,
3. radiotoxicity,
4. chemical and physical form of the material and the geometrical shape,
5. environment in which it is to be used,
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our source designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

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## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

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**Certificate no.** 218942-2

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.
To determine the emission rate, the absorption of the capsule has to be taken into account.
The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 501 |
| Activity | 36.10 kBq (975.7 nCi) Caesium-137 |
| Date of measurement of activity | 24 March 1988 |
| Overall uncertainty* | ± 3 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |
| Integrity ISO/BSI/DIN/ANSI Classification | C.34313 |
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

Traceability: The activity of the source above-mentioned has been measured against a reference source, calibrated by the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig.

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787 R1000

## ..ity control

### Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005μCi.
(This test conforms to BS 5288/Appendix D.2·1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanediol) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS 5288/Appendix D.3·1 except that for some sources, the 100mm³ free volume requirement is not met).

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005μCi.
(This test conforms to BS 5288/Appendix D.2·3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005μCi.
(This test conforms to BS 5288/Appendix D.2·4)

**Helium mass spectrograph test H**
Limit: leak rate of $10^{-6}$ standard cm³/sec.
(This test used conforms to either BS 5288/Appendix D.3·4 or D.3·5, but our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting. (DWIGHT D. J. Radiochemical Centre Report R.176.) The limit corresponds to about $5 \times 10^{-11}$Ci per 24 hours.
(This test conforms to BS 5288/Appendix D.2·6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations.
(IAEA Safety Series No. 6, 1967/1973 revised edition†).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are:
impact test
percussion test
bending test (only for long, slender sources)
heat test.
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

†1973 regulations not yet universally adopted.

## Source working life

The *'recommended working life'* is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
Adverse environments could affect the appearance and integrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the "recommended working life" the source should be replaced.

## ISO Classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned".

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

### Table 1. Classification of sealed source performance standards

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 170MPa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibration | No test | 30min 25Hz to 500Hz at 5gn peak amplitude | 30min 25Hz to 50Hz at 5gn peak amplitude and 50Hz to 500Hz at 0·635mm amplitude peak to peak and 50Hz to 500Hz at 10gn | 90min 25Hz to 80Hz at 1·5mm amplitude peak to peak and 80Hz to 2000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO.2919 and BS.5288. A further class X can be used where a special test procedure has been adopted.
2. External pressure
   100kPa = 1 atmosphere (approx.)
3. Impact test
   The source, positioned on a steel anvil, is struck by a steel hammer of the required weight, the hammer has a flat striking surface, 25mm diam. with the edges rounded.
4. Puncture test
   The source, positioned on a hardened steel anvil, is struck by a hardened pin, 5mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

### Table 2. Sealed source performance requirements for typical uses

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (excluding gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 5 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or daily transported) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source application (excluding reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 30μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 2 | 4 |
| | Source in device | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 2 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 2 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Interstitial and intracavitary applicators* | 5 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deformation in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:
1. consequences of loss of activity,
2. quantity of active material contained in the source,
3. radiotoxicity,
4. chemical and physical form of the material and the geometrical shape,
5. environment in which it is to be used,
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our source designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

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## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

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**Certificate no.** 218942-4

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.

To determine the emission rate, the absorption of the capsule has to be taken into account.

The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 503 |
| Activity | 38.42 kBq (1.038 µCi) Cobalt-60 |
| Date of measurement of activity | 24 March 1988 |
| Overall uncerta...y* | ± 3 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |
| Integrity ISO/BSI/DIN/ANSI Classification | C.34313 |
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

** See overleaf for description of tests

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

Remarks

Traceability: The activity of the source above-mentioned has been measured against a reference source, calibrated by the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig.

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## ·y control

### Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanediol) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS.5288/App. D.3.1, except that for some sources, the 100mm³ free volume requirement is not met).

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005μCi.
(This test conforms to BS.5288/App. D. 2·4)

**Helium mass spectrograph test N**
Limit: leak rate of $10^{-6}$ standard cm³/sec.
(This test used conforms to either BS.5288/App. D.3·4 or D.3·5, but our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting. (DWIGHT D. J. Radiochemical Centre Report R.176.)
The limit corresponds to about $5 \times 10^{-11}$Ci per 24 hours.
(This test conforms to BS.5288/App. D. 2·6, but our limit is 200 times more stringent).

## IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations.
(IAEA Safety Series No. 6. 1967/1973 revised edition†).

It is used in determining the maximum acceptable activities for various types of transport containers.

The required tests are:
impact test
percussion test
bending test (only for long, slender sources)
heat test.
After each test the source must be subjected to immersion testing.

The certificate (SFC) numbers given are those issued by the Dept. of the Environment, the competent authority in the UK for administering the IAEA regulations.

† 1973 regulations not yet universally adopted

## Source working life

The *'recommended working life'* is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
Adverse environments could affect the appearance and integrity of a source. It is the user's responsibility to regularly inspect and test the source in order to assess at what point during the "recommended working life" the source should be replaced.

## ISO Classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO.2919).

"This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products under working conditions. It also assists a user of such sealed sources to select types which suit the application he has in mind, especially where protection against the release of radioactive material is concerned".

The tests to which specimen sources are subjected are listed in Table 1.
Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.
These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.
C indicates that the activity level of the source does not exceed the prescribed limit and
E that the limit is exceeded.

### Table 1. Classification of sealed source performance standards

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 170MPa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibrations | No test | 30min 25Hz to 500Hz at 5gn peak amplitude | 30min 25Hz to 50Hz at 5gn peak amplitude and 50Hz to 80Hz at 0·635mm amplitude peak to peak and 80Hz to 500Hz at 10gn | 90min 25Hz to 80Hz at 1·5mm amplitude peak to peak and 80Hz to 3000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO 2919 and BS.5288. A further class X can be used where a special test procedure has been adopted.
2. External pressure
   100kPa = 1 atmosphere (approx.)
3. Impact test
   The source, positioned on a steel anvil, is struck by a steel hammer of the required weight, the hammer has a flat striking surface, 25mm diam. with the edges rounded.
4. Puncture test
   The source, positioned on a hardened steel anvil, is struck by a hardened pin, 6mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

### Table 2. Sealed source performance requirements for typical uses

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected source | 4 | 3 | 5 | 1 | 5 |
| | Source in device | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected source | 4 | 3 | 3 | 3 | 3 |
| | Source in device | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (excluding gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 8 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or daily transported) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source application (excluding reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 30μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected source | 4 | 3 | 4 | 2 | 4 |
| | Source in device | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be tested) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 3 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 3 |
| | Gamma teletherapy | 5 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 5 | 3 | 3 | 2 | 2 |
| | Interstitial and intracavitary applicators* | 5 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 3 |

*Sources of this nature may be subject to severe deterioration in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:
1. consequences of loss of activity.
2. quantity of active material contained in the source.
3. radiotoxicity.
4. chemical and physical form of the material and the geometrical shape.
5. environment in which it is to be used.
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our sources designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

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## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

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**Certificate no.** 218942-5

Date 6 April 1988 ku/wo

The activity of the source described thereafter had been determined by comparison with a standard source of the same nuclide.
To determine the emission rate, the absorption of the capsule has to be taken into account.
The source passed the leakage test.

| | |
|---|---|
| Type | ASSET811 (QCR811) |
| Source No | AT 504 |
| Activity | 28.9 kBq (781 nCi) Manganese-54 |
| Date of measurement of activity | 25 March 1988 |
| Overall uncertainty* | ± 5 % |
| Capsule | 1 mm plastic (density 1.23 g/cm³) |
| Integrity ISO/BSI/DIN/ANSI Classification | C.34313 |
| Leakage test and result | L and A |
| Date of leakage test | 31 March 1988 |

* This estimate of uncertainty was calculated in accordance with the recommendation of the International Commission on Radiation Units and Measurements (ICRU Report 12). The limits of uncertainty were taken as the arithmetic sum of the uncertainty due to random variations, calculated at the 99.7 % confidence level and the estimated maximum systematic uncertainty in the measurement.

** See overleaf for description of tests

Remarks

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## ..y control

### Testing for leakage and contamination

Stringent tests for leakage are an essential feature of radioactive sources production. The methods adopted depend on the design and intended application of the source, and also on statutory requirements. Where necessary, tests can be specially modified to meet particular requirements.

The standard methods used for testing radiation sources are listed below.

**Wipe test A**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·1)

**Wipe test B**
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Limit: 0·05μCi.

**Bubble test D**
The source is immersed in a suitable liquid (ethanediol) and the pressure in the vessel reduced to 100mm of mercury. No bubbles must be observed.
(This test conforms to BS.5288/App. D.3·1, except that for some sources, the 100mm² free volume requirement is not met)

**Immersion test F**
The source is immersed in water at 50°C for 8 hours and the activity in the water measured.
Limit: 0·05μCi.

**Immersion test L**
The source is immersed in water at 50°C for 4 hours and the activity in the water measured.
Limit: 0·005μCi.
(This test conforms to BS.5288/App. D.2·3)

**Immersion test M**
The source is immersed in water which is raised to 100°C and held at that temperature for 10 min. The water is then removed, the source cooled, and the procedure repeated twice. Sources are passed if the activity extracted in the final procedure does not exceed 0·005μCi.
(This test conforms to BS.5288/App. D. 2·4)

**Helium mass spectrograph test H**
Limit: leak rate of $10^{-6}$ standard cm³/sec.
(This test used conforms to either BS.5288/App. D.3 4 or D.3 5, but our limit is much more stringent).

**Emanation test K**
**(scintillation counting test for radon)**
The appliance is immersed in a solution of a phosphor in an organic liquid under vacuum; the leakage of radon is measured by liquid scintillation counting. (DWIGHT D J Radiochemical Centre Report R.176.)
The limit corresponds to about $5 \times 10^{-11}$Ci per 24 hours.
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The *'recommended working life'* is our recommendation of the period within which the source should be replaced. The period given has been assessed on the basis of such factors as, toxicity of nuclide, total initial activity, source construction (eg capsule design, source insert type, etc), half-life of nuclide, typical application environments, operational experience, test performance data, etc.
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The tests to which specimen sources are subjected are listed in Table 1.
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E that the limit is exceeded.

### Table 1. Classification of sealed source performance standards

| Test | Class 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Temperature | No test | −40°C (20 min) +80°C (1 h) | −40°C (20 min) +180°C (1 h) | −40°C (20 min) +400°C (1 h) and thermal shock 400°C to 20°C | −40°C (20 min) +600°C (1 h) and thermal shock 600°C to 20°C | −40°C (20 min) +800°C (1 h) and thermal shock 800°C to 20°C |
| External pressure | No test | 25kPa absolute to atmospheric pressure | 25kPa absolute to 2 MPa absolute | 25kPa absolute to 7MPa absolute | 25kPa absolute to 70MPa absolute | 25kPa absolute to 170MPa absolute |
| Impact | No test | 50g from 1m | 200g from 1m | 2kg from 1m | 5kg from 1m | 20kg from 1m |
| Vibration | No test | 30min 25Hz to 500Hz at 5gn peak amplitude | 30min 25Hz to 80Hz at 5gn peak amplitude and 80Hz to 500Hz at 0·635mm amplitude peak to peak and 80Hz to 500Hz at 10gn | 90min 25Hz to 80Hz at 1·5mm amplitude peak to peak and 80Hz to 2000Hz at 20gn | | |
| Puncture | No test | 1g from 1m | 10g from 1m | 50g from 1m | 300g from 1m | 1kg from 1m |

**Notes to Table 1**

1. Details of the testing procedures are given in ISO 2919 and BS.5288. A further class X can be used where a special test procedure has been adopted.
2. External pressure
   100kPa = 1 atmosphere (approx.)
3. Impact test
   The source, positioned on a steel anvil, is struck by a steel hammer of the required weight, the hammer has a flat striking surface, 25mm diam. with the edges rounded.
4. Puncture test
   The source, positioned on a hardened steel anvil, is struck by a hardened pin, 5mm long, 3mm diam. with hemispherical end, fixed to a hammer of the required weight.

## Performance requirements for typical uses

Typical applications in which sealed radioactive sources may be used, with minimum performance requirements are also given in ISO.2919 (see Table 2 below). These recommendations take into account normal usage and reasonable accidental risks, but do not include exposure to the risk of fire, explosion or corrosion.

### Table 2. Sealed source performance requirements for typical uses

| Sealed source use | | Sealed source test and class: Temperature | Pressure | Impact | Vibration | Puncture |
|---|---|---|---|---|---|---|
| Industrial radiography | Unprotected sources | 4 | 3 | 5 | 1 | 5 |
| | Sources in devices | 4 | 3 | 3 | 1 | 3 |
| Gamma gauges (medium and high energy) | Unprotected sources | 4 | 3 | 3 | 3 | 3 |
| | Sources in devices | 4 | 3 | 2 | 3 | 2 |
| Beta gauges and sources for low energy gamma gauges or X-ray fluorescence analysis (excluding gas-filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil well logging | | 5 | 6 | 5 | 2 | 2 |
| Portable moisture and density gauges (including hand held or daily transported) | | 4 | 3 | 3 | 3 | 3 |
| General neutron source application (excluding reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration sources, activity greater than 30μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma irradiation sources | Unprotected sources | 4 | 3 | 4 | 2 | 4 |
| | Sources in devices | 4 | 3 | 3 | 2 | 3 |
| Ion generators (source-device combination may be sealed) | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static eliminators | 2 | 2 | 2 | 2 | 2 |
| | Smoke detectors | 3 | 2 | 2 | 2 | 2 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 2 |
| | Gamma teletherapy | 6 | 3 | 5 | 2 | 4 |
| | Beta teletherapy | 6 | 3 | 3 | 2 | 2 |
| | Interstitial and intracavitary applicators* | 5 | 3 | 2 | 1 | 1 |
| | Surface applicators | 4 | 3 | 3 | 1 | 2 |

*Sources of this nature may be subject to severe deformation in use. Manufacturers and users may wish to formulate additional or special test procedures.

If the sealed source has a 'C' classification, Table 2 can be used directly to assess the suitability of the source for the proposed application provided that there is no significant fire, explosion or corrosion hazard.

If such a hazard does exist, the user and the manufacturer have to consider the following factors to determine whether additional testing is required:

1. consequences of loss of activity,
2. quantity of active material contained in the source,
3. radiotoxicity,
4. chemical and physical form of the material and the geometrical shape,
5. environment in which it is to be used,
6. protection afforded to the source or source-device combination.

If the sealed source has an 'E' classification, Table 2 cannot be used directly.

To determine whether any additional testing is necessary, an evaluation of the fire, explosion and corrosion hazards must first be made and a separate evaluation of the use and design of the source.

Some of our source designs exceed the recommendations of Table 2 and may therefore be acceptable for the applications listed despite the 'E' classification.

Acknowledgement: Tables from BS.5288·1976 are reproduced by permission of BSI, 2 Park Street, London W1A 2BS from whom complete copies can be obtained.

## Laboratory applications

The ISO classification system does not refer explicitly to sources designed for research laboratory usage because of the wide variety of applications and environments in which such sources might be used.

## Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.

Users should therefore consult our technical staff before using sources in potentially adverse environments.

# V. Air Flow

SAIC
An Employee-Owned Company

RADECO
A Division of Science Applications International Corporation

# CERTIFICATE OF CALIBRATION

DATE OF CALIBRATION June 6, 1989

CUSTOMER SAIC-Las Vegas P.O. NO. N/A

MODEL NO. C-812 SERIAL NO. 1549

BAROMETRIC PRESSURE: ACTUAL 30.02"Hg CORRECTED TO: 29.92" Hg

TEMPERATURE: ACTUAL 73°F CORRECTED TO: 70°F

FILTER PAPER USED: N/A CARTRIDGE USED: N/A

LAMINAR FLOW ELEMENT 50MW20-1-½ SERIAL NO. 713010-X1-R3

MANOMETER MODEL NO. 40HE35WM SERIAL NO. 704320U1

NBS TEST REFERENCE NOS. 2.6/167716A & B, 232.09/209275-B

| FLOW CFM | REFERENCE Inches $H_2O$ | CALIBRATION DATA AS LEFT Inches $H_2O$ | CALIBRATION DATA AS FOUND Inches $H_2O$ |
|---|---|---|---|
| 0.5 | 0.161 | 0.160 | 0.168 |
| 1.0 | 0.322 | 0.320 | 0.335 |
| 1.5 | 0.484 | 0.485 | 0.499 |
| 2.0 | 0.646 | 0.645 | 0.670 |
| 2.5 | 0.808 | 0.810 | 0.840 |
| 3.0 | 0.971 | 0.970 | 1.009 |

Unit Was Received X Within ____ Outside of ±5% Accuracy.

This is to certify that SAIC RADECO in San Diego, California, has on this date, certified this instrument to be within ±5% accuracy at each calibration point. The laminar flow element referenced above bears Letters of Certification traceable to the National Bureau of Standards.

CALIBRATED BY [signature] QUALITY ASSURANCE [signature]

SAIC - RADECO.

A Division of Science Applications International Corporation

# CERTIFICATE OF CALIBRATION
# AIR FLOW CALIBRATOR

CUSTOMER SAIC-Las Vegas

DATE April 25, 1988

MODEL NO. C-812

SERIAL NO. 1549

MERIAM SERIAL NO. 713010-X1-R2

MANOMETER SERIAL NO. 704320U1

BAROMETRIC PRESSURE: ACTUAL 30.04"

CORRECTED TO: 29.92"

TEMPERATURE: ACTUAL 70°F

CORRECTED TO: 70°F

[1] NEW UNIT

[2] CALIBRATION AS RECEIVED

[3] RE-CALIBRATION DATA

| FLOW CFM | REFERENCE Inches $H_2O$ | [2] MEASURED Inches $H_2O$ | [3] MEASURED Inches $H_2O$ |
|---|---|---|---|
| 0.5 | 0.164 | 0.172 | 0.165 |
| 1.0 | 0.328 | 0.333 | 0.330 |
| 1.5 | 0.493 | 0.496 | 0.495 |
| 2.0 | 0.658 | 0.663 | 0.660 |
| 2.5 | 0.823 | 0.831 | 0.825 |
| 3.0 | 0.989 | 0.990 | 0.990 |

NBS TEST REF. #'s: 2.6/167716A & B, 232.09/209275-B

This is to certify that SAIC/RADECO™ in San Diego, California, has on this date, certified this model to be within ± 5% accuracy at each calibration point. The "Meriam Laminar Flow Element" referenced above, bears Letters of Certification traceable to the National Bureau of Standards.

CALIBRATED BY _____ QUALITY ASSURANCE _____

## B. Kurz Mass Flow Meter Model 1544

KURZ INSTRUMENTS INC.

# CERTIFICATE OF CONFORMANCE

## KURZ INSTRUMENTS. INC.

REFERENCE PURCHASE ORDER: 14-890055-65

PURCHASE ORDER DATE: 6/23/88

MODEL NUMBER: 1544

SERIAL NUMBER: MBE 1565N

DATE: 8/18/88

WE HEREBY CERTIFY THAT THE PRODUCT(S) SUPPLIED. COMPLETELY CONFORM TO THE SPECIFICATIONS IN THE ABOVE REFERENCED PURCHASE ORDER. AND TO THE CURRENT REVISION OF THE KURZ Q.A. MANUAL.

Jim Bell QUALITY ASSURANCE

JIM BELL. Q.A. MANGER

8/18/88 DATE

2411 GARDEN ROAD MONTEREY, CA 93940 TLX 172275 (800)424-7356 NATIONWIDE (408) 646-5911 FAX (408)646-8901

K-CC (3/88)

CUSTOMER COPY

KURZ INSTRUMENTS INC.

# CERTIFICATE OF COMPLIANCE AND CALIBRATION

## KURZ INSTRUMENTS, INC.

THIS IS TO CERTIFY THAT THE EQUIPMENT LISTED BELOW HAS BEEN CALIBRATED WITH EQUIPMENT TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS, AND THE ACCURACY RATIO OF THE EQUIPMENT TO THE ITEM BEING CALIBRATED IS AT LEAST 4 TO 1 OR BETTER.

CUSTOMER PURCHASE ORDER: 14-890055-65

KURZ MODEL NUMBER: 1544

KURZ SERIAL NUMBER: MBE 1565N

RANGE OF INSTRUMENT: 0-200SLPM

ACCURACY: ± 2% OF READING .+½% OF FULL SCALE

REPEATABILITY: ± .25% OF FULL SCALE

CALIBRATION STANDARDS USED

MERIAM INSTRUMENTS, INC. - LAMINAR FLOW ELEMENT

MODEL: 50MW20-1"F

SERIAL NUMBER: 1032

DATE CALIBRATED: 8/21/87 DATE DUE: 8/21/88

NBS TRACEABILITY TEST NUMBERS: 2.6/167716 A&B
232.09/[illegible]

Jim Bell

QUALITY ASSURANCE

JIM BELL, QA MANAGER

8/18/88

DATE

2411 GARDEN ROAD MONTEREY, CA 93940 TLX 172275 (800)424-7356 NATIONWIDE (408) 646-5911 FAX (408)646-8901

K-CCC (3/88)

CUSTOMER COPY

MODEL 1544

KURZ INSTRUMENTS INC.

# CALIBRATION DATA AND CERTIFICATION

CODE 198 302

S/N MBE 1565N

| FLOW | RANGE | UNIT | OUTPUT V/I | DUCT PIPE | CALIBRATION INSTRUMENTS | DUE DATE |
|---|---|---|---|---|---|---|
| VELOCITY | | | | SIZE: | LFE S/N 1032 | 8-21-88 |
| | | | | I.D. | TEMP GAUGE S/N T-10 | 9-15-88 |
| MASS | 0-200 | SLPM | V 0-2.000 | AREA | DVM 1 S/N 318331 | 3-7-89 |
| | | | I | | DVM 2 S/N | |
| PRESSURE | GAS | TEMP RANGE | | BV Ø 3.418 | BAROMETER S/N 115050-Y1 | — |
| | | | | BV MAX 8.209 | FREQ CTR S/N | |

| | VELOCITY | MASS FLOW | INDICATED FLOW | CURRENT SENSE VOLTAGE | OUTPUT VOLTAGE | OUTPUT CURRENT ma |
|---|---|---|---|---|---|---|
| 1 | | 200 | 200.0 | | 2.000 | |
| 2 | | 180 | 182.1 | | 1.822 | |
| 3 | | 160 | 161.5 | | 1.616 | |
| 4 | | 140 | 140.7 | | 1.408 | |
| 5 | | 120 | 121.6 | | 1.217 | |
| 6 | | 100 | 100.9 | | 1.010 | |
| 7 | | 80 | 80.1 | | .802 | |
| 8 | | 60 | 61.1 | | .612 | |
| 9 | | 40 | 40.8 | | .409 | |
| 10 | | 20 | 20.2 | | .203 | |
| 11 | | 10 | 10.4 | | .105 | |
| 12 | | Ø | Ø | | Ø | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | | | | | | |
| 18 | | | | | | |

Document Reviewed By Quality Assurance

Signed: [illegible]

NBS TRACEABLE FLOW DATA -SEE ABOVE

CALIBRATION TECHNICIAN [illegible]

DATE 8-11-88

STANDARD CONDITIONS 25oC and 760 mm Hg.

* "ACTUAL FLOW" Represents flow data points using NBS calibration.

** "INDICATED FLOW" Represents a direct reading on an analog or digital meter. Indicated flow is the calculated flow for a linear unit based on full scale output voltage and full scale flow rate.

This form is to confirm that this instrument was calibrated with an NBS traceable mass flow meter and associated equipment. This calibration device is traceable to National Bureau of Standards. Test Numbers 2.6/167716 A&B 232.08/208275.8.

K-CDC 6/88

KURZ INSTRUMENTS, INC. - 2411 GARDEN RD. - MONTEREY, CA 93940
TLX 172275 - (408) 646-5911 - 1-800-4-AIRFLO NATIONWIDE (1-800-424-7356)

## C. Kurz Mass Flow Meter Model 490

KURZ INSTRUMENTS INC.

# CERTIFICATE OF CONFORMANCE

## KURZ INSTRUMENTS. INC.

REFERENCE PURCHASE ORDER: 14-890055-65

PURCHASE ORDER DATE: 6/23/88

MODEL NUMBER: 490

SERIAL NUMBER: LVE3179I

DATE: 8/18/88

WE HEREBY CERTIFY THAT THE PRODUCT(S) SUPPLIED. COMPLETELY CONFORM TO THE SPECIFICATIONS IN THE ABOVE REFERENCED PURCHASE ORDER. AND TO THE CURRENT REVISION OF THE KURZ Q.A. MANUAL.

Jim Bell QUALITY ASSURANCE

JIM BELL. Q.A. MANGER

8/18/88 DATE

2411 GARDEN ROAD MONTEREY, CA 93940 TLX 172275 (800)424-7356 NATIONWIDE (408) 646-5911 FAX (408)646-5901

K- CC (3/88)

CUSTOMER COPY

KURZ INSTRUMENTS INC.

# CERTIFICATE OF COMPLIANCE AND CALIBRATION

## KURZ INSTRUMENTS, INC.

THIS IS TO CERTIFY THAT THE EQUIPMENT LISTED BELOW HAS BEEN CALIBRATED WITH EQUIPMENT TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS, AND THE ACCURACY RATIO OF THE EQUIPMENT TO THE ITEM BEING CALIBRATED IS AT LEAST 4 TO 1 OR BETTER.

CUSTOMER PURCHASE ORDER: 14-890055-65 -

KURZ MODEL NUMBER: 490

KURZ SERIAL NUMBER: LVE3179I

RANGE OF INSTRUMENT: 0-200/0-2000FPM

ACCURACY: ± 2% OF READING .+½% OF FULL SCALE

REPEATABILITY: ± .25% OF FULL SCALE

CALIBRATION STANDARDS USED

MERIAM INSTRUMENTS, INC. - LAMINAR FLOW ELEMENT

MODEL: 50MC2-2F

SERIAL NUMBER: 1049

DATE CALIBRATED: 5/16/88 DATE DUE: 5/16/89

NBS TRACEABILITY TEST NUMBERS: 2.6/167716 A&B
832.09/209275-B

Jim Bell
QUALITY ASSURANCE

JIM BELL, QA MANAGER

8/18/88
DATE

2411 GARDEN ROAD MONTEREY, CA 93940 TLX 172275 (800)424-7356 NATIONWIDE (408) 646-5911 FAX (408)646-8901

K-CCC (3/88)

CUSTOMER COPY

BU'L = .885
BU'H = 1.824

KURZ INSTRUMENTS INC.

2411 GARDEN ROAD
MONTEREY, CA 93940
(408) 646-5911
TELEX 172275
1-800-4-AIRFLO
NATIONWIDE (1-800-424-7356)

# LETTER OF CERTIFICATION OF TRACEABILITY TO NATIONAL BUREAU OF STANDARDS

MODEL NO. 490 SERIAL NO. LUE 3174 I

LFE S/N 1049 DATE DUE 5-16-89

DVM S/N 2095 DATE DUE 5-17-89

TEMP. GAUGE S/N T-2 DATE DUE 8-5-88

BAROMETER S/N 115080 41 DATE DUE —

FREQ. CTR. S/N — DATE DUE —

THIS FORM IS TO CONFIRM THAT THIS INSTRUMENT WAS CALIBRATED WITH AN NBS TRACEABLE MASS FLOW METER AND ASSOCIATED EQUIPMENT. THIS CALIBRATION DEVICE IS TRACEABLE TO NATIONAL BUREAU OF STANDARDS, TEST NUMBERS 2.6/167716 A&B 232.09/209.275.B

SIGNED [illegible]

DATE 8-4-88

IRE
037

$BU_L$ = .885
$BU_H$ = 1.824

KURZ INSTRUMENTS INC.
2411 GARDEN ROAD
MONTEREY, CA 93940
(408) 646-5911
TELEX 172275
1-800-4-AIRFLO
NATIONWIDE (1-800-424-7356)

# LETTER OF CERTIFICATION OF TRACEABILITY TO NATIONAL BUREAU OF STANDARDS

MODEL NO. 490 SERIAL NO. LUE 3179 I

LFE S/N 1049 DATE DUE 5-16-89

DVM S/N 2095 DATE DUE 5-17-89

TEMP. GAUGE S/N T-2 DATE DUE 8-5-88

BAROMETER S/N 115080 41 DATE DUE —

FREQ. CTR. S/N — DATE DUE —

THIS FORM IS TO CONFIRM THAT THIS INSTRUMENT WAS CALIBRATED WITH AN NBS TRACEABLE MASS FLOW METER AND ASSOCIATED EQUIPMENT. THIS CALIBRATION DEVICE IS TRACEABLE TO NATIONAL BUREAU OF STANDARDS, TEST NUMBERS 2.6/167716 A&B 232.09/209.275.B

SIGNED [illegible]

DATE 8-4-88

Document Reviewed By
Quality Assurance
Signed A. Shabe

D. Anderson Constant Air Flow Pump Model SE112

# ANDERSEN
SAMPLERS INCORPORATED

CALIBRATION DATA

MODEL SE 112

SERIAL NUMBER 785-372

TEMPERATURE 77° F

BAROMETRIC PRESSURE 76.39 cm Hg

| INDICATED FLOW RATE (LPM) | ACTUAL FLOW RATE (LPM) |
|---|---|
| 2 | 2.02 |
| 4 | 3.97 |
| 6 | 5.80 |
| 8 | 7.67 |
| 10 | 9.70 |

SIGNED Nathan D Camp

DATE 9-22-87

4215 WENDELL DRIVE □ ATLANTA, GEORGIA 30336 □ (404) 691-1910 □ TELEX: 54-2523

ANDERSEN
SAMPLERS INCORPORATED

CALIBRATION DATA

MODEL SE 112

SERIAL NUMBER 785-371

TEMPERATURE 77° F

BAROMETRIC PRESSURE 76.39 cm Hg

| INDICATED FLOW RATE (LPM) | ACTUAL FLOW RATE (LPM) |
|---|---|
| 2 | 1.89 |
| 4 | 3.83 |
| 6 | 5.65 |
| 8 | 7.54 |
| 10 | 9.56 |

SIGNED Nathan D Camp

DATE 9-22-87

4215 WENDELL DRIVE □ ATLANTA, GEORGIA 30336 □ (404) 691-1910 □ TELEX: 54-2523

# VI. Mass/Volume/Length

# VII. Temperature/Barometric Pressure/Humidity

EVER READY THERMOMETER CO., New York, N.Y. 10157

# LABORATORY TEST CERTIFICATE

**Liquid-in-Glass Thermometer**

*Marked* – ERTCO

*Instrument No.* N-67692

*Thermometer Scale Range* - 1 *to* 51 °C *in* 0.1 ° *divisions*

*Tested for*
ERTCO

**RESULTS OF TEST**

| Thermometer Reading | Correction |
|---|---|
| + 0.02 °C | - 0.02 °C |
| 10.00 | - .06 |
| 20.00 | - .04 |
| 30.00 | - .02 |
| 37.00 | .00 |
| 40.00 | - .02 |
| 50.00 | - .02 |

**If the correction is preceded by a + sign, it should be added to the thermometer reading; if it is preceded by a – sign, it should be subtracted from the thermometer reading to obtain the temperature. To use the corrections properly, reference should be made to the notes on the reverse side of this sheet.**

Test No. 138887

Date 10-28-87

EVER READY THERMOMETER CO.

Certified by _____

# VIII. Electronic/Electrical

## A. Pulsers/Signal Generators

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

LUDLUM MEASUREMENTS, INC.
915 · 235-5494 - 235-4947 TELEX No. 466832 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

# CERTIFICATE OF CONFORMANCE & INSPECTION

CUSTOMER: SCIENCE APPLICATIONS INTERNATIONAL CORP.
LAS VEGAS, NV

DATE: 1-31-89 CUSTOMER PO# 14-88025-65 LUDLUM ORDER # 884867

CATALOG # 48-1677 MODEL & SERIAL # 1500 #61737

THE INSTRUMENTS OR ITEMS ARE IN CONFORMANCE WITH THE MANUFACTURER'S AND AS APPLICABLE, CUSTOMER'S SPECIFICATIONS PURSUANT TO THE ABOVE REFERENCED PURCHASE ORDER/CONTRACT NUMBER AND HAVE MET OR EXCEEDED LUDLUM MEASUREMENTS, INC. QUALITY ASSURANCE PROCEDURES REQUIREMENTS FOR MATERIAL INSPECTION, TEST, AND CALIBRATIONS.

INSTRUMENT CALIBRATION METHODOLOGIES ARE PERFORMED PER STANDARD OPERATION PROCEDURES NUMBERS 14.8, 14.9, AND 14.10

INSTRUMENT CALIBRATIONS OR OPERATION MAY BE EFFECTED BY CERTAIN EXTERNAL CONDITIONS OR TEMPERATURE, HUMIDITY, BAROMETRIC PRESSURE OR DAMAGE DURING SHIPPING.

THE UNDERSIGNED IS AN AUTHORIZED REPRESENTATIVE OF LUDLUM MEASUREMENTS, INC.

ITEM # 7
REQUIREMENT II

QUALITY ASSURANCE MANAGER
LUDLUM MEASUREMENTS, INC.

**LUDLUM MEASUREMENTS, INC.**
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET TELEX No. 466832 UD
SWEETWATER, TEXAS, U. S. A. PH. 915-235-5494

## CERTIFICATE OF CALIBRATION

CUSTOMER SAIC ORDER NO. 88-4867
Mfg. Ludlum Model 500 Serial No. 61737
Mfg. _____ Det. Model _____ Serial No. _____
Cal. Date 1-11-89 Cal. Due Date 1-11-90 Cal. Interval 1 year METERFACE _____
Check mark ( ) applies to applicable instr. and/or detector IAW mfg. spec, s. ☑ New Instrument
☐ Det. (Alpha) Bkgnd _____ cpm ☐ Det. Oper. V _____ V at _____ MV
Temp. _____ Humidity _____ % ☐ F/S Resp. ck ☐ Zero Reset ck. ☐ Audio ck. ☑ Meter Zeroed
☐ Bat. ck. (Min. Volt) _____ VDC ☐ Bat. Volt _____ VDC Instrument Volt Set _____ V
☐ Threshold Dial _____ Input Sens _____ mV. ☐ Input Sens Linearity
☐ HV Readout (2 points) Ref./Inst _____ / _____ V Ref./Inst _____ / _____ V
☐ Alarm Setting ck. ☐ Window Operation ☐ Background subtract ☑ Mechanical ck.
☐ Field Change Status _____
Repair Instrument Received: ☐ Within Toler. + -10% ☐ 10-20% ☐ Out Toler. ☐ Requiring Repair

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M. 44-9 in which the back of probe faces source.

| RANGE MULTIPLIER | REFERENCE CAL. POINT | INSTRUMENT METER READING | INSTRUMENT REC'D "AS FOUND READING" |
|---|---|---|---|
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |
| X | | | |

Range(s) Calibrated Electronically

| | Reference Cal. Point | Instrument Meter Reading | "As Found Reading" |
|---|---|---|---|
| Digital Readout | / / / / / | / / / / / | / / / / / |
| Log Scale | / / / / / | / / / / / | / / / / / |

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Bureau of Standards, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of MIL-STD-45662A and ANSI N323-1978.

State of Texas Calibration License No. LO-[illegible]

☐ Cs137 Gamma s/n 1162 ☐ Neutron Am-241 Be s/n T-304
☐ Alpha s/n _____ ☐ Beta s/n _____ ☑ Other BeK Frequency Counter #82-04793
☐ M-500 s/n _____ ☑ Oscilloscope s/n 03618 ☑ Multimeter s/n 15573

Calibrated By: Linda Murphy Date 1-11-89
Reviewed By: Larry Bell Date 1-11-89

Form 22 — 3/88

see note on back

DESIGNER AND MANUFACTURER
OF
*Scientific and Industrial Instruments*

# LUDLUM MEASUREMENTS, INC.

915 · 235-5494 - 235-4947 TELEX No. 466882 UD
POST OFFICE BOX 810 FAX NO. (915) 235-4672
501 OAK STREET
SWEETWATER, TEXAS, U. S. A. 79556

CALIBRATION CERTIFICATE LUDLUM MODEL 500 S/N 61732

Counts/Minute

| Range | Pulser Setting | Reference Counter + or - 2% | Pulser Setting | Reference Counter + or - 2% |
|---|---|---|---|---|
| .1 | 250 | 25 | 750 | 75 |
| 1 | " | 250 | " | 751 |
| 10 | " | 2500 | " | 7507 |
| 100 | " | 25000 | " | 75084 |
| 1K | " | 249944 | " | 750470 |
| 10K | " | 2498810 | " | 7500350 |

Amplitude

| Range | Amplitude Setting | Amplitude Reading + or - 5% | Amplitude Setting | Amplitude Reading + or - 5% |
|---|---|---|---|---|
| 5 mV | 1 | 1mv. | 4 | 3.9mv. |
| 50 mV | " | 10mv. | " | 39mv. |
| 500 mV | " | 100mv. | " | 390mv. |
| 5 V | " | 1v. | " | 3.9v. |

High Voltage

| Setting | Reading + or - 5% |
|---|---|
| 700 | 710 |
| 2000 | 2050 |

Reference Counter M 2200 S/N 46354
Reference Voltmeter ~~BK 2530~~ Simpson #43 S/N 15573
Reference Scope BK 147 S/N 03618

* B&K model 1820 Frequency Counter SN 82-04793 NBS Cal. cert. # 44659

Date 1-11-89 Calibrated By Linda Murphy
Supervisor Larry Bell

Form 16 * Cal. cert. for B&K instrument identifies SN as 62-04793 not 82-04793 as indicated above 2/16/89

# JOHN FLUKE MFG. CO., INC.

EXTENDING THE QUALITY

JOHN FLUKE MFG. CO. INC.
FLUKE
METROLOGY SYSTEMS
SEAL OF CERTIFIED CALIBRATION
CUSTOMER SUPPORT SERVICES

FLUKE TECHNICAL CENTER
[illegible] VON KARMAN AVE [illegible]
IRVINE, CA [illegible]

656659

SCIENCE APPLICATIONS INC
SAIC
101 CONVENTION CENTER DR
SUITE [illegible]
LAS VEGAS NV [illegible]
ANN KIPP
702-794-[illegible]

▲ SUBMITTED BY

| | MODEL/PART NO | SERIAL NO | ACCESSORIES/PARTS INCLUDED |
|---|---|---|---|
| FOR: | MISC | 89-19369 | BK3020 |

| | CALIBRATION STATUS | CAL CONDITIONS | |
|---|---|---|---|
| RECEIVED | IN TOLERANCE | 23 | °C |
| RETURNED | IN TOLERANCE | 40 | % RH |

## CERTIFICATE OF CALIBRATION

The John Fluke Mfg. Co., Inc. does hereby certify the above listed instrument meets or exceeds all published specifications and has been calibrated using standards whose accuracies are traceable to the National Bureau of Standards within the limitations of the Bureau's Calibration Services, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of self-calibration techniques.

| APPLICABLE NBS NUMBERS | |
|---|---|
| DC VOLTAGE | 235339 |
| AC VOLTAGE | 234877 |
| RESISTANCE | 235396 |
| TEMPERATURE | 229053 |
| FREQUENCY | VLF WWVB |

1.00 70.00

TECH. NO. 168

CERTIFIED BY

RON FERNANDEZ 02/22/89

SERVICE MANAGER CALIBRATION DATE

CALIBRATION DATA
IN AND OUT DATA
MODEL: B&K 3020 SERIAL#: 89-19309
FEBRUARY 21, 1989

PREQUENCY ACCURACY:

+ 5% OF FULL SCALE TO 1.5 MHZ,
+ 8% FROM 1.5 MHZ TO 2 MHZ,
SINEWAVE OUTPUT.

| | | |
|---|---|---|
| 10 HZ | = | 10.0 HZ |
| 100 HZ | = | 100.6 HZ |
| 1000 HZ | = | 1.007KHZ |
| 10KHZ | = | 10.122KHZ |
| 100KHZ | = | 101.761KHZ |
| 1MHZ | = | 1.04647MHZ |

OUTPUT AMPLITUDE:

| | | | |
|---|---|---|---|
| 20V P-P OPEN CIRCUIT - | MAX. | = | 21.9 VAC |
| 10V P-P INTO 50 OHMS - | MAX. | = | 11.2 VAC |

ATTENUATION:

REF. +10DOM
100KHZ SINEWAVE

| | | | |
|---|---|---|---|
| 10db STEP | = | 9.99 | db |
| 20db STEP | = | 20.0 | db |
| 20db STEP | = | 19.9 | db |

DISTORTION:
SINEWAVE,

| | |
|---|---|
| 1% 10HZ TO 100KHZ - | < 1% 10HZ TO 100KHZ |
| 3% 100KHZ TO 2MHZ - | < 3% 100KHZ TO 2MHZ |

SWEEP RATE:

| | |
|---|---|
| 0.5 HZ (2 SEC. PERIOD) TO - | > 2 SEC ALL RANGES |
| 50 HZ (20M SEC. PERIOD) - | > 20M SEC ALL RANGES |

## B. Oscilloscope

# JOHN FLUKE MFG. CO., INC.

EXTENDING THE QUALITY

JOHN FLUKE MFG. CO. INC.
FLUKE
METROLOGY SYSTEMS
SEAL OF CERTIFIED CALIBRATION
CUSTOMER SUPPORT SERVICES

FLUKE TECHNICAL CENTER
[illegible] VON KARMAN AVE., [illegible]
IRVINE, CA [illegible]

056000

SCIENCE APPLICATIONS INT
SAIC
101 CONVENTION CENTER DR
SUITE [illegible]
LAS VEGAS NV [illegible]
ANN KIRK
702-794-[illegible]

SUBMITTED BY

| | MODEL/PART NO | SERIAL NO | ACCESSORIES/PARTS INCLUDED |
|---|---|---|---|
| FOR: | MISC | 02416 | BK1590 |

| | CALIBRATION STATUS | CAL CONDITIONS |
|---|---|---|
| RECEIVED | IN TOLERANCE | 23 °C |
| RETURNED | IN TOLERANCE | 40 %RH |

## CERTIFICATE OF CALIBRATION

The John Fluke Mfg. Co., Inc. does hereby certify the above listed instrument meets or exceeds all published specifications and has been calibrated using standards whose accuracies are traceable to the National Bureau of Standards within the limitations of the Bureau's Calibration Services, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of self-calibration techniques.

| APPLICABLE NBS NUMBERS | |
|---|---|
| DC VOLTAGE | 235339 |
| AC VOLTAGE | 234877 |
| RESISTANCE | 235396 |
| TEMPERATURE | 229053 |
| FREQUENCY | VLF WWVB |

[illegible]

TECH. NO. 168

CERTIFIED BY

RON FERNANDEZ — 02/22/89

SERVICE MANAGER — CALIBRATION DATE

CALIBRATION DATA
IN AND OUT DATA
MODLE: B&K1590A SERIAL#: 02416
FEBRUARY 21, 1989

| | |
|---|---|
| SWEEP TIME/DIVISION: | AS MEASURED |
| + 2% ALL STEPS | < 2% ALL STEPS |
| VOLTS PER DIVISION: | |
| + 2% ALL STEPS | < 2% ALL STEPS |
| FREQUENCY RESPONSE: | |
| 5HZ TO 100MHZ(-3db) INCLUDING X5 GAIN MODE | > 125 MHZ -3db POINT |
| RISE TIME: | |
| 3.5 NS | 3.4NS |
| TRIGGERING SENSITIVITY: | |
| DC-100MHZ 1.5 DIV | < 1.0 DIV. |
| AC 10 TO 100MHZ 1.5 DIV | < 1.0 DIV. |
| AUTO 50HZ TO 100MHZ 1.5 DIV | < 1.0 DIV. |
| VIDEO FRAME .5 DIV | .5 DIV. |
| VIDEO LINE .5 DIV | .5 DIV. |
| CALIBRATION OUT PUT: | |
| 1 KHZ SQUARE WAVE +3% | < 2% |
| 1 VPP +1% | + 1% |
| 10 MA P-P +2% | + 2% |

C. Voltmeters/Ampmeter/Ohmmeter

# JOHN FLUKE MFG. CO., INC.

XTENDING THE QUALITY

JOHN FLUKE MFG. CO. INC.
FLUKE
METROLOGY SYSTEMS
SEAL OF CERTIFIED CALIBRATION
CUSTOMER SUPPORT SERVICES

FLUKE TECHNICAL CENTER
[illegible] VON KARMAN AVE., [illegible]
IRVINE, CA [illegible]

656664

▲ CALIBRATED BY

SCIENCE APPLICATIONS INC
SAIC
101 CONVENTION CENTER DR
SUITE 407
LAS VEGAS NV [illegible]
ANN KIRK
702-794-7151

▲ SUBMITTED BY

| | MODEL/PART NO | SERIAL NO | ACCESSORIES/PARTS INCLUDED |
|---|---|---|---|
| FOR: | 8024B | 4480363 | NONE |

| | CALIBRATION STATUS | CAL CONDITIONS |
|---|---|---|
| RECEIVED | IN TOLERANCE | 23 °C |
| RETURNED | IN TOLERANCE | 40 %RH |

## CERTIFICATE OF CALIBRATION

The John Fluke Mfg. Co., Inc. does hereby certify the above listed instrument meets or exceeds all published specifications and has been calibrated using standards whose accuracies are traceable to the National Bureau of Standards within the limitations of the Bureau's Calibration Services, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of self-calibration techniques.

| APPLICABLE NBS NUMBERS | |
|---|---|
| DC VOLTAGE | 235339 |
| AC VOLTAGE | 234877 |
| RESISTANCE | 235396 |
| TEMPERATURE | 229053 |
| FREQUENCY | VLF WWVB |

[illegible]

TECH. NO. 137

CERTIFIED BY

RON FERNANDEZ 02/22/89

SERVICE MANAGER CALIBRATION DATE

CALIBRATION DATA
FLUKE MODEL 8024B SERIAL #4480363
DATE 2-20-89

| PARAMETER | NOMINAL | MEASURED | TOLERANCE |
|---|---|---|---|
| DC VOLT RANGE | | | |
| 200MV | 190.0 MV | 190.00 V | + 3 DIGITS |
| 200MV | - 190.0 MV | - 190.00 V | + 3 DIGITS |
| 2 V | 1.900 V | 1.900V | + 3 DIGITS |
| 20 V | 19.00 V | 19.00 V | + 3 DIGITS |
| 200 V | 190.0 V | 190.00 V | + 3 DIGITS |
| 1000 V | 1000 V | 1000 V | + 3 DIGITS |
| DC LINEARITY 20V RANGE | | | |
| | 2.00 V | 2.00 V | + 1 DIGITS |
| | 3.00 V | 3.00 V | + 1 DIGITS |
| | 4.00 V | 4.00 V | + 1 DIGITS |
| | 5.00 V | 5.00 V | + 2 DIGITS |
| | 6.00 V | 6.00 V | + 2 DIGITS |
| | 7.00 V | 7.00 V | + 2 DIGITS |
| | 8.00 V | 8.00 V | + 2 DIGITS |
| | 9.00 V | 9.00 V | + 2 DIGITS |
| | 10.00 V | 10.00 V | + 2 DIGITS |
| | 11.00 V | 11.00 V | + 2 DIGITS |
| | 12.00 V | 12.00 V | + 2 DIGITS |
| | 13.00 V | 13.00 V | + 2 DIGITS |
| | 14.00 V | 14.00 V | + 2 DIGITS |
| | 15.00 V | 15.00 V | + 3 DIGITS |
| | 16.00 V | 16.00 V | + 3 DIGITS |
| | 17.00 V | 17.00 V | + 3 DIGITS |
| | 18.00 V | 18.00 V | + 3 DIGITS |
| | 19.00 V | 19.00 V | + 3 DIGITS |

| AC VOLT RANGE | | | | |
|---|---|---|---|---|
| 200MV | 190.0 MV | 100 HZ | 190.0 V | + 16 DIGITS |
| 200MV | 190.0 MV | 5 HZ | 186.4 V | + 100 DIGITS |
| 2 V | 1.900 V | 100 HZ | 1.898V | + 16 DIGITS |
| 2 V | 1.900 V | 5KHZ | 1.875V | + 100 DIGITS |
| 20 V | 19.00 V | 100 HZ | 19.00 V | + 16 DIGITS |
| 20 V | 19.00 V | 5KHZ | 18.80 V | + 100 DIGITS |
| 200 V | 100.0 V | 2KHZ | 100.0 V | + 18 DIGITS |
| 200 V | 190.0 V | 100 HZ | 190.1 V | + 16 DIGITS |
| 200 V | 190.0 V | 2KHZ | 190.2 V | + 31 DIGITS |
| 750 V | 750. V | 100 HZ | 750. V | + 9 DIGITS |
| 750 V | 750. V | 1KHZ | 750. V | + 9 DIGITS |

| PARAMETER | NOMINAL | MEASURED | TOLERANCE |
|---|---|---|---|
| DC CURRENT TEST | | | |
| 2mA | 1.900mA | 1.900mA | + 15 DIGITS |
| 20mA | 19.00 mA | 18.97 mA | + 15 DIGITS |
| 200mA | 190.0 mA | 190.1 mA | + 15 DIGITS |
| 2000mA | 1900 mA | 1901 mA | + 15 DIGITS |
| 2000mA | - 1900 mA | - 1901 mA | + 15 DIGITS |
| RESISTANCE TEST | | | |
| 20M | 10.00 M OHMS | 10.00 M OHMS | + 20 DIGITS |
| 2000K | 1000 K OHMS | 999 K OHMS | + 5 DIGITS |
| 200K | 100.0 K OHMS | 99.9 K OHMS | + 5 DIGITS |
| 20K | 10.00 K OHMS | 9.99 K OHMS | + 5 DIGITS |
| 2K | 1.000K OHMS | 1.000K OHMS | + 5 DIGITS |
| 200 | 100.0 OHMS | 99.9 OHMS | + 9 DIGITS |
| 200 | 00.0 | - 00.1 OHMS | + 2 DIGITS |

| PARAMETER | APPLIED | DISPLAY READING | MEASURED | TOLERANCE |
|---|---|---|---|---|
| CONDUCTANCE TEST | | | | |
| 2ms | 1K OHMS | 1.000 | N/A | + 3 DIGITS |
| 200ms | 10K OHMS | 100.0 | 100.0 ms | + 30 DIGITS |

## D. Voltage/Current Sources

# JOHN FLUKE MFG. CO., INC.

FLUKE TECHNICAL CENTER
[illegible] VON KARMAN AVE., [illegible] 656661
IRVINE, CA 92714

SUBMITTED BY

SCIENCE APPLICATIONS INC
SAI
101 CONVENTION CENTER DR
SUITE 497
LAS VEGAS NV 89109
ANN KIRK
702-794-7151

SUBMITTED BY

XTENDING THE QUALITY

JOHN FLUKE MFG. CO. INC. — FLUKE — METROLOGY SYSTEMS — SEAL OF CERTIFIED CALIBRATION — CUSTOMER SUPPORT SERVICES

| | MODEL/PART NO | SERIAL NO | ACCESSORIES/PARTS INCLUDED |
|---|---|---|---|
| FOR: | MISC | 24-32603 | BK1601 |

| | CALIBRATION STATUS | CAL CONDITIONS |
|---|---|---|
| RECEIVED | IN TOLERANCE | 23 °C |
| RETURNED | IN TOLERANCE | 40 % RH |

## CERTIFICATE OF CALIBRATION

The John Fluke Mfg. Co., Inc. does hereby certify the above listed instrument meets or exceeds all published specifications and has been calibrated using standards whose accuracies are traceable to the National Bureau of Standards within the limitations of the Bureau's Calibration Services, or have been derived from accepted values of natural physical constants, or have been derived by the ratio type of self-calibration techniques.

| APPLICABLE NBS NUMBERS | |
|---|---|
| DC VOLTAGE | 235339 |
| AC VOLTAGE | 234877 |
| RESISTANCE | 235396 |
| TEMPERATURE | 229053 |
| FREQUENCY | VLF WWVB |

TECH. NO. 168

CERTIFIED BY

RON FERNANDEZ — 02/22/89

SERVICE MANAGER — CALIBRATION DATE

CALIBRATION DATA
IN AND OUT DATA
MODEL: B&K 1601 SERIAL#: 24-32603
FEBRUARY 21, 1989

| OUT PUT VOLTAGE | DIAL | ACTUAL |
|---|---|---|
| 0-25V RANGE | 5 VDC | 4.91 VDC |
| | 10 | 9.92 VDC |
| | 15 | 14.98 VDC |
| | 20 | 19.98 VDC |
| | 25 | 25.34 VDC |
| 0-50V RANGE | 10 | 9.69 VDC |
| | 20 | 19.50 VDC |
| | 30 | 29.36 VDC |
| | 40 | 39.0 VDC |
| | 50 | 49.8 VDC |
| OUT PUT CURRENT | | |
| 0.2A RANGE | .1 | .10 ADC |
| | .2 | .20 ADC |
| 2A RANGE | .5 | .48 ADC |
| | 1 | .99 ADC |
| | 1.5 | 1.48 ADC |
| | 2 | 2.00 ADC |

# IX. Other