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AUTH.NAME AUTHOR AFFILIATION
CONWAY,W.F. Arizona Public Service Co. (formerly Arizona Nuclear Power
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EXECUTIVE VICE PRESIDENT
NUCLEAR

102-02886-WFC/AKK/DLK
March 29, 1994

U. S. Nuclear Regulatory Commission
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References: 1. Letter dated November 30, 1993, from B. E. Holian, USNRC, to W. F. Conway, APS, "Summary of Meeting Held on October 19, 1993, to Discuss Radiation Monitor Calibration Methods"

2. Letter 102-02741, dated November 29, 1993, from W. F. Conway, APS, to USNRC, "Reply to Notice of Deviation 50-528/93-03-01"

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
Technical Justification for the Containment High-Range Radiation Monitor Calibration Methodology
File: 94-016-545; 94-056-026

Representatives from Arizona Public Service Company (APS) met in Washington DC with the Office of Nuclear Reactor Regulation (NRR) to present the calibration methodology, used by APS, for the containment high-range radiation monitors and to provide a forum, at a working group level, for questions and answers. A summary of the meeting and the overheads used are included in Reference 1. By letter dated November 29, 1993 (Reference 2), APS committed to forward to NRR the technical justification, along with surveillance test results that correlated the performance of the containment high-range radiation monitors to the primary calibration (performed by the manufacturer). Enclosure 1 to this letter is the technical justification. The surveillance test results that correlate the performance of the containment high-range monitors to the primary calibration (performed by the manufacturer) are included in Enclosure 2.

A001

[illegible]

Should you have any questions, please contact Angela K. Krainik at (602) 393-5421.

Sincerely,

WFConway

WFC/AKK/DLK/rv

Enclosures:
1. Technical Justification
2. Test Results Correlation to the Primary Calibration

cc: K. E. Perkins, Jr.
K. E. Johnston

ENCLOSURE 1

TECHNICAL JUSTIFICATION

FOR

CONTAINMENT HIGH-RANGE RADIATION MONITOR CALIBRATION

METHODOLOGY

TECHNICAL JUSTIFICATION FOR CONTAINMENT HIGH-RANGE MONITOR CALIBRATION METHODOLOGY

Arizona Public Service Company (APS) uses a transfer calibration methodology to verify detector accuracy and operability through the use of a transfer radiation source. APS' transfer calibration procedure is essentially the procedure specified by the equipment manufacturer to comply with the NUREG-0737 recommendations, and is consistent with the transfer calibration methodology used by the two other major manufacturers of containment radiation monitors.

No stipulation is made in Table II.F.1-3 of NUREG-0737 that an in situ calibration needs to fulfill the same requirements of a primary calibration. Moreover, the NUREG does not specifically endorse the use of an external calibration source, nor does it prohibit the use of an internal calibration source. It simply recommends that "in situ calibration for at least one decade below 10 R/hr shall be by means of a calibrated radiation source." Based on correspondence and discussions with the Office of Nuclear Reactor Regulation (NRR), APS recognizes that NRR interprets this recommendation to imply the use of a calibrated external source. This submittal presents the technical basis and justification supporting the use of an alternate in situ transfer calibration methodology using a source internal to the detector. It demonstrates that using an internal source is technically equivalent to using an external source when performing transfer calibrations and meets the overall intent of the in situ calibration recommendations contained in Table II.F.1-3 of NUREG-0737.

The basis for the APS' transfer calibration methodology can be explained by examining the following three areas:

- the differences between primary and transfer in situ calibrations, and the ability of the transfer calibration source to serve as a "calibrated radiation source";
- the dual role of the Am-241 source and the specific procedural requirements imposed that allow it to be used as a transfer calibration standard; and
- the principles of ion chamber operation that allow the use of an internally mounted alpha emitter (Am-241) to demonstrate the accuracy and functionality of an ion chamber used to measure external beta/gamma radiation.

Primary vs. Transfer Calibration

The purpose of a primary calibration is to quantify the performance characteristics of a particular design of radiation detector. Primary calibrations of each detector having the same design are not necessary as long as subsequent calibrations correlate each detector's response to radiation to the response measured on the specific detector that underwent the primary calibration. This is typically accomplished using radioactive solid

sources measured in a fixed geometry. During the primary calibration, the detector's response to these sources is measured and recorded. Subsequent calibrations on other detectors of the same design require that these detectors have the same response to the same sources (or other sources made with the same isotopes and geometry), as measured on the detector that underwent the primary calibration. This calibration methodology is known as a transfer calibration. The purpose of a transfer calibration is only to verify that the response of each detector to radiation is similar to the response measured on the detector that underwent a primary calibration. The sources used are referred to as "transfer calibration" sources. If the transfer calibration is performed in the field, as opposed to removing the detector from the field and transporting it to a calibration facility, the transfer calibration is referred to as an in situ calibration.

The following describes the five basic parts of the primary calibration performed on the containment high-range radiation monitors used at Palo Verde.

1) Electronic Alignment - In the case of containment high-range area monitors, this consists of setting detector operating voltage and performing an electronic calibration of the detection channel using a suitable pico amp current source. . This methodology is described in NUREG-0737 recommendations.

2) Energy Calibration - Since collection efficiency of an ion chamber depends on ion density, and not on how the ionization is produced, the linearity characteristics of the ion chamber should be independent of the type or spectrum of the radiation involved (provided that the intensity of the radiation field is reasonably uniform over the volume of the ionization chamber). Furthermore, since ion chambers of a particular design can be manufactured so that they are essentially identical, this calibration can be performed on a "type" basis. For the containment high-range monitors, this calibration was performed to demonstrate a sensitivity to photon energies as low as 60 KeV and an essentially flat response of the detection system in terms of exposure rate in the incident photon energy range of 0.1 to 3.0 MeV. The energy calibration was performed as part of the primary calibration and is documented in "Report of Calibration, Model KDA-HR Ion Chamber Detector (P/N 824636-001)", Kaman Report Number: K-82-70-U(R).

3) Linearity Testing - This consists of exposing the detector to widely spaced points in its measurement range and verifying linear response. For containment high-range detectors, this test is accomplished for exposure rates through 10^7 R/hr on a type basis for the same reasons explained above. Linearity testing was performed as part of the primary calibration and is documented in "Report of Calibration, Model KDA-HR Ion Chamber Detector (P/N 824636-001)", Kaman Report Number: K-82-70-U(R). Every

subsequently manufactured detector that is purchased is tested through 10^3 R/hr. When these detectors are purchased, calibration data documenting this test is supplied with the detector. This methodology follows the guidance recommended in NUREG-0737 and later clarified by D. G. Eisenhut.[1]

4) Primary Calibration - For containment high-range detectors, this consists of exposing the detector in an NIST (formerly NBS) traceable gamma radiation field and establishing the output of the detector in terms of R/hr/amp referenced to a particular isotope (generally, Cesium (Cs-137) or Cobalt (Co-60)). This part of the calibration was performed in conjunction with the linearity testing described above. Therefore, each detector installed in the field undergoes a primary calibration (exposure through 10^3 R/hr) before it is shipped by the manufacturer to ensure correct response.

5) Transfer Source Testing - This test consists of exposing the detector to a source that will serve as a transfer standard to ensure proper operation at subsequent field <u>in situ</u> calibrations. The response to the transfer calibration source observed during the primary calibration is correlated to the expected response in the field. As long as the responses are similar, the detector is expected to respond to radiation in the field as it did during the primary calibration. The transfer calibration source becomes a "calibrated source" when it is linked to the primary calibration by this method. The transfer source is used only as a link of traceability to the primary calibration and need not be NIST traceable. In the case of the containment high-range monitor, the manufacturer records each detector response to the internal Am-241 source observed during linearity and primary calibration testing (through 10^3 R/hr) performed at the factory. This information is supplied with every detector. The Am-241 source response measured and recorded as part of the primary calibration forms the link between the primary calibration and subsequent field calibrations making the Am-241 acceptable as a transfer calibration source.

While <u>all</u> parts of the primary calibration process discussed above are important to quantify the performance characteristics of the detector, not all of the parts are required to be repeated in the field in order to verify detector accuracy and operability. Due to design configuration control, full range linearity and energy response testing are performed by the manufacture on a "type" basis. Because of ALARA considerations, the detection efficiency and linearity of each production detector is verified to be the same

[1] Letter dated August 16, 1982, from D. G. Eisenhut, USNRC, to Regional Administrators, "Proposed Guidance for Calibration and Surveillance Requirements for Equipment Provided to Meet Item II.F.1, Attachments 1, 2, and 3, NUREG-0737"

as the type tested detectors through 10^3 R/hr before they are installed in the field. This calibration may be performed by the manufacturer. Therefore, the in situ transfer calibration performed on the containment high-range monitors need only consist of electronic alignment and verification of the transfer source response in order to ensure that the monitor is functioning accurately for its intended purpose. This overall methodology is consistent with the specific recommendations presented in NUREG-0737.

All three major US manufacturers of containment high-range area monitoring systems follow this calibration methodology and utilize a transfer calibration method to verify that the detector and monitor are functioning accurately after field installation. Palo Verde Nuclear Generating Station is no exception.

By way of comparison, Victoreen Instrument Corporation follows the methodology as stated establishing traceability to the primary calibration through the use of a modified version of the Victoreen Field Calibration Kit (FCK). The Victoreen FCK consists of a Cs-137 source mounted in a shielded holder that fixes the detector to source geometry. The FCK is not directly NIST traceable in terms of exposure rates. Traceability is linked only to the source response observed during the primary calibration.

GA/Sorrento Electronics uses a similar method in the form of their RT-11 calibrator. Again, a Cs-137 source in a shielded holder is used. The holder is subsequently hung on the side of the detector in a known geometry. The RT-11 is not NIST traceable in terms of exposure rate. Traceability is only linked to the primary calibration.

Although other manufacturers decided to utilize external transfer calibration sources, Kaman elected to use an internal source. The Palo Verde Nuclear Generating Station calibration method is essentially the method prescribed by the original equipment manufacturer (Kaman) with tighter tolerances applied to the transfer source response. In this case, the transfer calibration source consists of an Am-241 source mounted in a fixed location within the detector itself. This source is present at all times and its output is directly traceable to the primary calibration of the detector.

NUREG-0737 recommended that the detector's response be verified with a "calibrated source". All three major manufacturers of containment high-range monitors use a transfer calibration methodology to accomplish this requirement and to routinely assess detector performance in the field. The use of any transfer source, externally or internally mounted, satisfies the intent of the NUREG-0737 recommendation to verify detector response, provided that it is traceable to the factory calibration and that it satisfactorily demonstrates the detector and monitor are functioning accurately after field installation.

Dual Role of Am-241

Am-241 is used as a check source to verify detector operability during continuous operation. The containment high-range monitor uses the continuous current response generated by the internal source to detect detector failure (i.e., a loss of detector signal). This is only one application of the internal source. PVNGS calibration procedures require the Am-241 source response fall within a prescribed range ($\pm$ 30%) of the response recorded during the primary calibration. Under this application, the PVNGS calibration procedures use the internal source response as a quantitative assessment which is directly traceable to the primary calibration. As such the PVNGS calibration procedure constitutes a "calibration." This is consistent with the transfer calibration methodology discussed above.

Use of Alpha Emitter to verify Ion Chamber Operation

An ion chamber detects radiation via its interaction with gas contained within the chamber. This interaction produces ions and electrons in an electric field that eventually are detected as a current response between the detector's electrodes. The type of gas in the detector, the type of radiation, or the energy of the radiation does not greatly effect the energy dissipation per ion pair produced by the interaction between the radiation and the gas. In other words, the energy dissipation of fast electrons and alpha particles is essentially the same, and the amount of energy deposited within the chamber is proportional to the number of ion pairs formed (ion density) by the interaction of the radiation with the gas.[2] Therefore, collection efficiency of the ion chamber depends on ion density produced within the chamber, and not on how the ionization originated.

The overall detector sensitivity to external radiation is a function of the mechanical design of the ion chamber (i.e., construction material, wall thickness, detector diameter, etc.). Since ion chambers of a particular model can be manufactured so that they are essentially identical with respect to mechanical design, the practice of type testing detectors becomes applicable. This is the basis for performing energy response and linearity testing through 10^7 R/hr in order to quantify response characteristics for a particular model of detector rather than repeat the test on each detector manufactured. Therefore, as long as the detectors are manufactured to the same mechanical design, the only parameters that can effect the ion collection efficiency within the chamber is the fill gas, its purity, fill pressure, and operating voltage.

Performing an electronic alignment and subsequent linearity testing through 10^3 R/hr on each detector manufactured ensures that the mechanical design of the detector and parameters affecting ion collection efficiency are consistent with that of the detectors that

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2 Knoll, Glenn F., Radiation Detection and Measurement, John Wiley and Sons, New York, NY, 1979 (pages 152-153).

were type tested for linearity and energy response. As part of this factory test, the response to the internal alpha source is recorded and the information is used later in subsequent field calibrations. When the detector is calibrated in the field it undergoes an electronic alignment and verification of its recorded response to the transfer calibration source (Am-241). The field test not only verifies that the ion collection efficiency of the detector has not changed but also verifies that the response of the detector is not affected by any inaccuracy of the electronic components used to measure the detector output or by any factor that could challenge connector and signal cable integrity. Because the detector mechanical design has already been verified in the laboratory and is not altered by field installation, it is not necessary to reverify the mechanical design by performing an in situ calibration in a known radiation field. Since ion collection efficiency within the chamber is independent of the type or energy of the radiation, either an alpha, beta, gamma, or beta/gamma source may be used to produce the ionization. Therefore, the use of an internally mounted alpha source rather than an external beta/gamma or gamma source can be used to test the parameters that affect ion collection efficiency within the chamber and operating characteristics of the monitor.

The use of a high activity beta/gamma or gamma source mounted externally in close proximity to the detector is not an adequate test to verify the mechanical design of the detector with respect to overall energy response because of the highly variable radiation fields. To test the overall energy response of an ion chamber detector, the detector should be exposed in a known radiation field that is relatively uniform with respect to the internal dimensions of the detector. Therefore, the use of an external transfer calibration source under these circumstances provides no advantage over the use of an internal Am-241 source. The same information regarding detector performance can be obtained from either type of source. In fact, the use of a high activity external source can induce a non conservative bias in the response if back scatter (a phenomenon caused by the interaction of the radiation with structures and equipment located near the detector) is not quantified or measured. The use of the internal Am-241 source eliminates back scatter effects.

Finally, NUREG-0737 recommends that the response of the detector be checked at one point below the range of 10 R/hr. The detector response from the internal Am-241 source produces a current that is within the range of 1E-11 to 5E-11 amps. Based on the detector efficiency of 1E+11 R/hr/amps, this response is equivalent to a response in the range of 1 to 5 R/hr. Therefore, the current response falls within the range recommended in NUREG-0737.

ENCLOSURE 2

SURVEILLANCE TEST RESULTS CORRELATION

TO

THE PRIMARY CALIBRATION

SURVEILLANCE TEST RESULTS CORRELATION TO THE PRIMARY CALIBRATION

As explained in the technical justification section, the particular model of containment high range detector used at Palo Verde was "type" tested to determine its detection efficiency to gamma radiation; its energy response characteristics; and its linearity characteristics through the range 10^7 R/hr. Results of the type test are documented in "Report of Calibration, Model KDA-HR Ion Chamber Detector (P/N 824636-001)", Kaman Report Number: K-82-70-U(R). Every subsequently manufactured detector purchased for field use was tested at the factory by exposing it to a calibrated radiation field in order to verify (relative to the type test) its detection efficiency and linearity through 10^3 R/hr. During this factory calibration, the detector response to the various radiation fields, along with the baseline current from the internal Am-241 source, were measured and recorded on factory calibration data sheets. The calibration data documenting this factory test were supplied with each detector purchased and are traceable by the detector serial number.

Figures 1 through 6 are copies of the data sheets supplied with the detectors currently installed at Palo Verde. The data sheets contain both the keep alive source reading observed at the time of calibration (identified on the data sheet for convenience) and the data collected when the detector was placed in a calibrated radiation field. The specific keep alive current response recorded during the factory calibration was incorporated into surveillance test procedure 74ST-9SQ23, "Radiation Monitoring Calibration Test for New Scope Monitors." The surveillance test procedure acceptance criteria are ± 30% of the keep alive source response measured during the factory calibration. The specific criteria used in the procedure are summarized in Table 1.

Table 1 - Keep Alive Source Current Data Summary

UNIT	MONITOR	DETECTOR SERIAL NUMBER	KEEP ALIVE CURRENT DURING FACTORY CALIBRATION (IN AMPS)	ALLOWABLE RANGE (IN AMPS)
1	RU-148	22706	1.38E-11	9.66E-12 TO 1.79E-11
	RU-149	22711	1.16E-11	8.12E-12 TO 1.51E-11
2	RU-148	22709	1.00E-11	7.00E-12 TO 1.30E-11
	RU-149	53364	2.00E-11	1.40E-11 TO 2.60E-11
3	RU-148	62165	2.38E-11	1.67E-11 TO 3.09E-11
	RU-149	62163	2.00E-11	1.40E-11 TO 2.60E-11

Finally, Figures 7-12 are copies of the applicable pages of 74ST-9SQ23 that were obtained from the most current calibrations performed on the containment high range monitors in all of the units. These data pages from the procedure demonstrate that the keep alive source response of the currently installed detectors fell within ± 30% of the source response measured during the factory calibration.

10.0 DATA SHEET - KDI-1000 PRIMARY CALIBRATION, Cs-137

Calibration Date 09 MAY 85 Customer/Channel HJ-SQA-RE-150
KI Detector Part No. 824636-003 Mfgr. Serial No. 22706

ITEM	MFGR	MODEL	S/N	CAL DUE
Picoammeter	KEITHLEY	616	627234	10 JUN 85
HV Supply	CANBERRA	3002	10784052	02 SEP 85
DVM	KEITHLEY	130	LV927	13 JAN 86

Keep-Alive Current (Acceptance Limits = 0.9 to 5.5 x E-11A):

18. Initial Reading .10 (E-9 Coulombs)
20. Final Reading 1.19 (E-9 Coulombs)
21. Time Interval 79 Second (60 seconds minimum)
22. Current = (Step 20 - Step 18)/Step 21 = 1.38 E-11 Amperes

KEEP ALIVE CURRENT

3.04 R/hr readings:

28. Initial Reading 1.00 (E-9) Coulombs .09
30. Final Reading 3.58 (E-9) Coulombs
31. Time Interval 60 Seconds (60 seconds minimum)
33. Current = (Step 30 - Step 28)/Step 31 = 4.30 E-11 Amperes
34. Net current (Step 33 - Step 22) = 2.92 E-11 Amperes
35. Efficiency (Step 34/3.04)) = .96 E-11 A/R/hr *

30.1 R/hr readings:

41. Gross current = 3.20 E-10 Amperes
43. Net current (Step 41 - Step 22) = 3.06 E-10 Amperes
44. Efficiency (Step 43/30.1) = 1.02 E-11 A/R/hr *

299 R/hr readings:

50. Gross current = 3.19 E-9 Amperes
52. Net current (Step 50 - Step 22) = 3.18 E-9 Amperes
53. Efficiency (Step 52/299) = 1.06 E-11 A/R/hr *

* Acceptance Limits = 0.8 to 1.2 x E-11 A/R/hr

By [signature] Date 09 MAY 85 QA [signature] Date 5-16-85

Figure 1 - Factory Calibration Data Sheet for Detector Serial Number 22706

10.0 DATA SHEET - KDI-1000 PRIMARY CALIBRATION, Cs-137

Calibration Date 09 MAY 85 . Customer/Channel 1-J-SQB-RE-49
KI Detector Part No. 82467-003 Mfgr. Serial No. 22711

ITEM	MFGR	MODEL	S/N	CAL DUE
Picoammeter	KEITHLEY	616	627234	10 JUN 85
HV Supply	CANBERRA	3002	10784052	02 SEP 85
DVM	KEITHLEY	130	LV427	13 JAN 86

Keep-Alive Current (Acceptance Limits = 0.9 to 5.5 x E-11A):

18. Initial Reading .10 (E-9 Coulombs)
20. Final Reading 1.14 (E-9 Coulombs)
21. Time Interval 90 Second (60 seconds minimum)
22. Current = (Step 20 - Step 18)/Step 21 = 1.16 E-11 Amperes

KEEP ALIVE CURRENT

3.04 R/hr readings:

28. Initial Reading 1.00 (E-9) Coulombs
30. Final Reading 3.38 (E-9) Coulombs
31. Time Interval 60 Seconds (60 seconds minimum)
33. Current = (Step 30 - Step 28)/Step 31 = 3.97 E-11 Amperes
34. Net current (Step 33 - Step 22) = 2.81 E-11 Amperes
35. Efficiency (Step 34/3.04)) = .92 E-11 A/R/hr *

30.1 R/hr readings:

41. Gross current = 3.13 E-10 Amperes
43. Net current (Step 41 - Step 22) = 3.01 E-10 Amperes
44. Efficiency (Step 43/30.1) = 1.00 E-11 A/R/hr *

299 R/hr readings:

50. Gross current = 3.03 E-9 Amperes
52. Net current (Step 50 - Step 22) = 3.02 E-9 Amperes
53. Efficiency (Step 52/299) = 1.01 E-11 A/R/hr *

* Acceptance Limits = 0.8 to 1.2 x E-11 A/R/hr

By [signature] Date 09 MAY 85 QA [signature] Date 5-16-85

Figure 2 - Factory Calibration Data Sheet For Detector Serial Number 22711

2-J-SQA-RE-150
450593-003
#U 31820-4

AREA MONITOR CALIBRATION: DATA SHEET
Palo Verde Unit 2, ch. RE-150

Detector Type Ion Chamber — High Voltage Mfgr. H/P
Mfgr. LND — Model 6516A
Model 50314 s/n 22709 — S/N 1824A04064
KIC Part No. 824636-002 — Cal. Due Functional *
Readout Type Picoammeter — Check Source/Live Zero
~~Source~~

Mfgr. Keithley — Source: Nuclide ^{241}Am Activity .08 μCi
Model 616 — Date 1982
S/N 62723A
Cal. Due 11/83

Test Location Penrose Hosp. — Calibration Date 6/9/83
Temperature 25°C Pressure 607.5 mmHg Relative Humidity <50%
Calibration Source I.D. Theratron-80
Nuclide ^{60}Co Activity 6802Ci Date 12/77
Beam Measuring Detector: Mfgr. Exradin Model .6cc S/N ID-1000
(For Verification of radiation field---NBS traceable) Type Ion Ch. Certificate See addendum pg

TEST DATA

High Voltage Setting +800 V — Acceptance Criteria
Other Instrument Settings (if applicable) — .8 to 1.2 (10^{-11}) A/R/hr

Check Source/Live Zero Reading 1.0 E-11 A

KEEP ALIVE CURRENT

Measured Field	Instrument Reading GROSS	NET	A/R/HR
.706 (10^3)mR/hr	1.7 E-11	.7 E-11	.99 E-11
.566 (10^4)mR/hr	6.5 E-11	5.5 E-11	.97 E-11
.584 (10^5)mR/hr	6.20 E-10	6.10 E-10	1.04 E-11
.756 (10^6)mR/hr	7.84 E-9	7.83 E-9	1.04 E-11

Tested with DVM Fluke Mod. 8020B s/n LV443, Cal due 10/24/83, at +800 V, 6/8/83

BECHTEL
631

Performer J. Miller — Date 6/9/83
QA E. Boyle — Date 6-21-83

Figure 3 - Factory Calibration Data Sheet for Detector Serial Number 22709

U-2 RU-149

10.0 DATA SHEET - KDI-1000 PRIMARY CALIBRATION, Cs-137

Calibration Date 10-25-85 Customer/Channel RU
KI Detector Part No. 824636-0009 Mfgr. Serial No. 53364

ITEM	MFGR	MODEL	S/N	CAL DUE
Picoammeter	Keithley	616	12057	6/10/86
HV Supply	Canberra	3002	20468	10/20/86
DVM				

Keep-Alive Current (Acceptance Limits = 0.9 to 5.5 x E-11A):

18. Initial Reading .11 (E-9 Coulombs)
20. Final Reading 1.40 (E-9 Coulombs)
21. Time Interval 64.3 Second (60 seconds minimum)
22. Current = (Step 20 - Step 18)/Step 21 = 2.00E-11 Amperes

KEEP ALIVE CURRENT

3.04 R/hr readings:

28. Initial Reading 1.13 (E-9) Coulombs
30. Final Reading 4.02 (E-9) Coulombs
31. Time Interval 63.79 Seconds (60 seconds minimum)
33. Current = (Step 30 - Step 28)/Step 31 = 4.55E-11 Amperes
34. Net current (Step 33 - Step 22) = 2.55 E-11 Amperes
35. Efficiency (Step 34/3.04)) = .829 E-11 A/R/hr *

30.1 R/hr readings:

41. Gross current = 2.70 E-10 Amperes
43. Net current (Step 41 - Step 22) = 2.50 E-10 Amperes
44. Efficiency (Step 43/30.1) = .830 E-11 A/R/hr *

299 R/hr readings:

50. Gross current = 2.68 E-9 Amperes
52. Net current (Step 50 - Step 22) = 2.66 E-9 Amperes
53. Efficiency (Step 52/299) = .889 E-11 A/R/hr *

* Acceptance Limits = 0.8 to 1.2 x E-11 A/R/hr

By Gary D. Dodge Date 10/25/85 QA QC Date OCT 25 '85

Figure 4 - Factory Calibration Data Sheet for Detector Serial Number 53364

U-3 RU-148 5478

10.6 DATA SHEET - RM-1000 PRIMARY CALIBRATION, Cs-137

Calibration Date 5-30-86 Customer/Channel N/A

XI Detector Part No. 824636-003 Mfgr. Serial No. 62165

ITEM	MFGR	MODEL	S/N	CAL DUE
Picoammeter	KEITHLEY	616	12459	6-1-86
HV Supply	CANBERRA	3002	LV468	10-20-86
DVM	FLUKE	8020A	LV302	2-9-87

Keep-Alive Current (Acceptance Limits = 0.9 to 5.5 x E-11A):

18. Initial Reading .10 (E-9 Coulombs)
20. Final Reading 1.53 (E-9 Coulombs)
21. Time Interval 60 Second (60 seconds minimum)
22. Current = (Step 20 - Step 18)/Step 21 = .0238E-9 Amperes

KEEP ALIVE CURRENT

3.04 R/hr readings:

28. Initial Reading 1.0 (E-9) Coulombs
30. Final Reading 3.89 (E-9) Coulombs
31. Time Interval 60 Seconds (60 seconds minimum)
33. Current = (Step 30 - Step 28)/Step 31 = .0482E-9 Amperes
34. Net current (Step 33 - Step 22) = .0244E-9 Amperes
35. Efficiency (Step 34/3.04)) = .802E-11 A/R/hr *

30.1 R/hr readings:

41. Gross current = 3.00 E-10 Amperes
43. Net current (Step 41 - Step 22) = 2.762 E-10 Amperes
44. Efficiency (Step 43/30.1) = .918E-11 A/R/hr *

299 R/hr readings:

50. Gross current = 2.80 E-9 Amperes
52. Net current (Step 50 - Step 22) = 2.78 E-9 Amperes
53. Efficiency (Step 52/299) = .9289E-11 A/R/hr *

* Acceptance Limits = 0.2 to 1.2 x E-11 A/R/hr

By [signature] Date 5-30-86 QA QC 19 Date [illegible]

Figure 5 - Factory Calibration Data Sheet for Detector Serial Number 62165

D-3 RU-149 194

10.0 DATA SHEET - KDI-1000 PRIMARY CALIBRATION, Cs-137

Calibration Date 5-30-86 Customer/Channel N/A

KI Detector Part No. 824636-003 Mfgr. Serial No. 62163

ITEM	MFGR	MODEL	S/N	CAL DUE
Picoammeter	KEITHLEY	616	12059	6-1-86
HV Supply	CANBERRA	3002	LV468	10-20-86
DVM	FLUKE	8020A	LV302	2-9-87

Keep-Alive Current (Acceptance Limits = 0.9 to 5.5 x E-11A):

18. Initial Reading .10 (E-9 Coulombs)
20. Final Reading 1.30 (E-9 Coulombs)
21. Time Interval 60 Second (60 seconds minimum)
22. Current = (Step 20 - Step 18)/Step 21 = .020 E-9 Amperes

KEEP ALIVE CURRENT

3.04 R/hr readings:

28. Initial Reading 1.0 (E-9) Coulombs
30. Final Reading 3.81 (E-9) Coulombs
31. Time Interval 60 Seconds (60 seconds minimum)
33. Current = (Step 30 - Step 28)/Step 31 = .0468 E-9 Amperes
34. Net current (Step 33 - Step 22) .0268 E-9 Amperes
35. Efficiency (Step 34/3.04)) = ~~.0027 E-9~~ .88816 E-11 A/R/hr *

30.1 R/hr readings:

41. Gross current = 3.10 E-10 Amperes
43. Net current (Step 41 - Step 22) = 2.90 E-10 Amperes
44. Efficiency (Step 43/30.1) = .963 E-11 A/R/hr *

299 R/hr readings:

50. Gross current = 2.92 E-9 Amperes
52. Net current (Step 50 - Step 22) = 2.90 E-9 Amperes
53. Efficiency (Step 52/299) = .969 E-11 A/R/hr *

* Acceptance Limits = 0.8 to 1.2 x E-11 A/R/hr

By [signature] 1/24 Date 5-30-86 QA QC 18 Date MAY 30 '86

Figure 6 - Factory Calibration Data Sheet for Detector Serial Number 62163

RADIATION MONITORING CALIBRATION TEST FOR NEW SCOPE AREA MONITORS	74ST-9SQ23	Revision 0.00

148 149

8.4.9 As Left Keep Alive

SU SU 8.4.9.1 Using SIMS, verify that the detector has not been replaced since the last calibration.

SU SU 8.4.9.1.1 If the detector has been replaced, verify that the detector serial number listed in step 8.4.9.4 matches the serial number of the current detector. (If the detector is inaccessible, obtain the serial number from a DDC file copy of the work package used to replace the detector.)

SU SU 8.4.9.2 At the KELIC, record the radiation level.

ALLOWABLE ≥1.00 E03 mr/hr

148/ 1.03E03

149/ 1.02 E03

SU SU 8.4.9.3 At the KELIC, place the LOCAL/REMOTE keyswitch in LOCAL.

SU SU 8.4.9.4 At the KELIC, place the monitor in the Calibrate Mode by pressing function keys 'FTN 1 06 1 ENT'. Record the Ion Chamber current level for the detector being checked. Mark the other unit detectors 'N/A'.

RU-148 DETECTOR

	DETECTOR SERIAL NUMBER	ALLOWABLE RANGE (IN AMPS)	AS LEFT VALUE
UNIT 1	22706	9.66E-12 TO 1.79E-11	1.07 E-11
UNIT 2	22709	7.00E-12 TO 1.30E-11	N/A
UNIT 3	62165	1.67E-11 TO 3.09E-11	N/A

Acceptance Criteria (Ref. 2.2.6.3)

Figure 7 - Calibration Data for RU-148, Unit 1
(WO # 00591469 Completed on 9/23/93)

RADIATION MONITORING CALIBRATION TEST FOR NEW SCOPE AREA MONITORS	74ST-9SQ23	Revision 0.00

148 149

RU-149 DETECTOR

	DETECTOR SERIAL NUMBER	ALLOWABLE RANGE (IN AMPS)	AS LEFT VALUE
UNIT 1	22711	8.12E-12 TO 1.51E-11	1.04 E-11
UNIT 2	53364	1.40E-11 TO 2.60E-11	N/A
UNIT 3	62163	1.40E-11 TO 2.60E-11	N/A

Acceptance Criteria (Ref. 2.2.6.3)

SU SU 8.4.9.5 At the KELIC, place the monitor in the Normal mode by pressing function keys "FTN 1 C6 0 ENT".

SU SU 8.4.9.6 At the KELIC, turn the LOCAL/REMOTE keyswitch to REMOTE.

8.4.10 Restoration of Monitor

SU SU 8.4.10.1 Ensure the monitor alarms and indications appear normal.

SU SU 8.4.10.2 Ensure the KERIC has been returned to normal and all alarms and indications appear normal.

SU SU 8.4.10.3 At the minicomputer terminal, place the monitor On Line by typing the monitor number then press function key UNIT ON.

RU-148 monitor number 42.
RU-149 monitor number 50.

SU N/A 8.4.10.4 For RU-148, proceed to section 8.5, RU-148 Functional Test.

N/A SU 8.4.10.5 For RU-149, proceed to section 8.6, RU-149 Functional Test.

Figure 8 - Calibration Data for RU-149, Unit 1
(WO # 00591469 Completed on 9/23/93)

148 149

8.4.9 As Left Keep Alive

8.4.9.1 Using SIMS, verify that the detector has not been replaced since the last calibration.

8.4.9.1.1 If the detector has been replaced, verify that the detector serial number listed in step 8.4.9.4 matches the serial number of the current detector. (If the detector is inaccessible, obtain the serial number from a DDC file copy of the work package used to replace the detector.)

8.4.9.2 At the KELIC, record the radiation level.

ALLOWABLE ≥1.00 E03 mr/hr

148/ 1.00 ~~E01~~ E03

149/ 1.00 E03

8.4.9.3 At the KELIC, place the LOCAL/REMOTE keyswitch in LOCAL.

8.4.9.4 At the KELIC, place the monitor in the Calibrate Mode by pressing function keys 'FTN 1 06 1 ENT'. Record the Ion Chamber current level for the detector being checked. Mark the other unit detectors 'N/A'.

RU-148 DETECTOR

	DETECTOR SERIAL NUMBER	ALLOWABLE RANGE (IN AMPS)	AS LEFT VALUE
UNIT 1	22706	9.66E-12 TO 1.79E-11	N/A
UNIT 2	22709	7.00E-12 TO 1.30E-11	8.15E-12
UNIT 3	62165	1.67E-11 TO 3.09E-11	N/A

Acceptance Criteria (Ref. 2.2.6.3)

Figure 9 - Calibration Data for RU-148, Unit 2
(WO # 00650676 Completed on 2/24/94)

RADIATION MONITORING CALIBRATION TEST FOR NEW SCOPE AREA MONITORS	74ST-9SQ23	Revision 0.00

148 149

RU-149 DETECTOR

	DETECTOR SERIAL NUMBER	ALLOWABLE RANGE (IN AMPS)	AS LEFT VALUE
UNIT 1	22711	8.12E-12 TO 1.51E-11	N/A
UNIT 2	53364	1.40E-11 TO 2.60E-11	2.16E-11
UNIT 3	62163	1.40E-11 TO 2.60E-11	N/A

Acceptance Criteria (Ref. 2.2.6.3)

8.4.9.5 At the KELIC, place the monitor in the Normal mode by pressing function keys "FTN 1 06 0 ENT"

8.4.9.6 At the KELIC, turn the LOCAL/REMOTE keyswitch to REMOTE.

8.4.10 Restoration of Monitor

8.4.10.1 Ensure the monitor alarms and indications appear normal.

8.4.10.2 Ensure the KERIC has been returned to normal and all alarms and indications appear normal.

8.4.10.3 At the minicomputer terminal, place the monitor On Line by typing the monitor number then press function key UNIT ON.

RU-148 monitor number 42.
RU-149 monitor number 50.

N/A 8.4.10.4 For RU-148, proceed to section 8.5, RU-148 Functional Test.

N/A 8.4.10.5 For RU-149, proceed to section 8.6, RU-149 Functional Test.

Figure 10 - Calibration Data for RU-149, Unit 2
(WO # 00650676 Completed on 2/24/94)

148 149

8.4.9 As Left Keep Alive

Ð SLK 8.4.9.1 Using SIMS, verify that the detector has not been replaced since the last calibration.

Ð SLK 8.4.9.1.1 If the detector has been replaced, verify that the detector serial number listed in step 8.4.9.4 matches the serial number of the current detector. (If the detector is inaccessible, obtain the serial number from a DDC file copy of the work package used to replace the detector.)

Ð SCA 8.4.9.2 At the KELIC, record the radiation level.

ALLOWABLE ≥1.00 E03 mr/hr

148/ ~~2.72 E03~~ Ð 8-19-92 ~~1.50~~ 1.00 E03 SLA 8.19.92 E03

149/ 1.01 E03

Ð SLA 8.4.9.3 At the KELIC, place the LOCAL/REMOTE keyswitch in LOCAL.

Ð SLA 8.4.9.4 At the KELIC, place the monitor in the Calibrate Mode by pressing function keys 'FTN 1 06 1 ENT'. Record the Ion Chamber current level for the detector being checked. Mark the other unit detectors 'N/A'.

RU-148 DETECTOR

	DETECTOR SERIAL NUMBER	ALLOWABLE RANGE (IN AMPS)	AS LEFT VALUE
UNIT 1	22706	9.66E-12 TO 1.79E-11	N/A
UNIT 2	22703	7.00E-12 TO 1.30E-11	N/A
UNIT 3	62165	1.67E-11 TO 3.09E-11	3.07E-11

Acceptance Criteria (Ref. 2.2.6.3)

Figure 11 - Calibration Data for RU-148, Unit 3
(WO # 00565171 Completed on 8/21/92)

148 149

RU-149 DETECTOR

	DETECTOR SERIAL NUMBER	ALLOWABLE RANGE (IN AMPS)	AS LEFT VALUE
UNIT 1	22711	8.12E-12 TO 1.51E-11	NA
UNIT 2	53364	1.40E-11 TO 2.60E-11	NA
UNIT 3	62163	1.40E-11 TO 2.60E-11	1.72 E-11

Acceptance Criteria (Ref. 2.2.6.3)

[initials] [initials] 8.4.9.5 At the KELIC, place the monitor in the Normal mode by pressing function keys 'FTN 1 06 0 ENT'.

[initials] [initials] 8.4.9.6 At the KELIC, turn the LOCAL/REMOTE keyswitch to REMOTE.

8.4.10 Restoration of Monitor

[initials] [initials] 8.4.10.1 Ensure the monitor alarms and indications appear normal.

[initials] [initials] 8.4.10.2 Ensure the KERIC has been returned to normal and all alarms and indications appear normal.

[initials] [initials] 8.4.10.3 At the minicomputer terminal, place the monitor On Line by typing the monitor number then press function key UNIT ON.

RU-148 monitor number 42.
RU-149 monitor number 50.

[initials] N/A 8.4.10.4 For RU-148, proceed to section 8.5, RU-148 Functional Test.

N/A [initials] 8.4.10.5 For RU-149, proceed to section 8.6, RU-149 Functional Test.

Figure 12 - Calibration Data for RU-149, Unit 3
(WO # 00565171 Completed on 8/21/92)