BF₃ GAMMA TOLERANT NEUTRON DETECTOR TUBES

DECEMBER 1975

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FOREWORD

This standard supersedes the August 1972 issue of RDT C 15-11T and incorporates those changes to that issue of the standard that were approved and published as Amendment 1. These changes are identified by the following marginal notations:

A1 Amendment 1, August 1974

Editorial changes that were made during preparation of this revision are not identified.

Significant editorial changes that have been incorporated in this revision include:

1. Addition of System International (SI) metric units.

2. Direct reference to RDT F 3-2T in 4.4.1 for calibration of test instruments.

3. Revision of the format to meet RDT F 1-1 requirements.
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BF₃ GAMMA TOLERANT NEUTRON DETECTOR TUBES

1. SCOPE

This standard covers the requirements for a high gamma tolerant, BF₃ filled proportional counter (also called detector) for use in neutron detection systems requiring operation in gamma flux environments to 10³ R/hr. This standard applies only to the detector; however, when used with other appropriate standards or specifications, it is intended that more complete assemblies (integral detector and cable or special shielded systems) can be obtained. Required performance characteristics are detailed, and the tests to assure this performance are described.

2. APPLICABLE DOCUMENTS

The following documents are a part of this standard to the extent specified in Sections 3 through 5. The issue of a document in effect on the date of the invitation to bid, including any amendments or other published changes also in effect, shall apply unless otherwise specified. Where this standard appears to conflict with the requirements of a reference document, such conflict shall be brought to the attention of the purchaser for resolution.

2.1 RDT Standards.

RDT C 18-1T Ceramic Electrical Insulators
RDT F 2-4T Quality Verification Program Requirements
RDT F 3-2T Calibration Program Requirements
RDT F 5-1T Cleaning and Cleanliness Requirements for Nuclear Components
RDT F 7-2T Packaging, Packing, and Marking of Components for Shipment and Storage

2.2 Drawings and Other Documents. Applicable drawings and other documents shall be as specified in the Ordering Data.

3. TECHNICAL REQUIREMENTS

3.1 General. This detector will be used to detect thermal neutrons in a neutron monitoring system. The detector will be installed in the near vicinity of a primary sodium piping system and will be subject to a gamma radiation environment. The usefulness of the system is strongly dependent upon maintaining a significant operating neutron sensitivity in the presence of background gamma radiation. Details of
the operating requirements and the environmental limitations are provided in the following sections.

Although this standard describes the requirements for a detector only, the configuration may require integral cables, special shielding (electromagnetic), or both. In the event that these requirements exist, they will be specified in the Ordering Data and the requirements and testing described herein shall apply to the entire assembly with the integral cable used in place of the cable specified in 4.4.1.5 (1).

3.2 Performance Requirements. The detector shall meet the performance requirements specified herein, while exposed to the environmental conditions given in 3.3.

3.2.1 Neutron Sensitivity. The thermal neutron sensitivity at room temperature, and without gamma radiation, shall be a minimum of 10 counts per (second·nv) at a discrimination level corresponding to 1 count per second and background noise contribution from all sources (usually the electronic system).

3.2.2 Neutron Sensitivity at 10³ R/hr Gamma. The usable thermal neutron sensitivity in a gamma field of 10³ R/hr shall be equal to or greater than 5 counts per (second·nv) with the system adjusted to permit no more than 1 count per second background caused by gamma-induced pulse pileup.

3.2.3 Neutron Sensitivity Variation with Temperature. At ambient temperatures ranging from room temperature to 300°F (149°C), the thermal neutron sensitivity in a gamma field as specified in 3.2.2 shall be within ±20 percent of the room temperature value.

3.2.4 Neutron Sensitivity Variation with Time. With the detector at operating conditions of 10³ R/hr ± 10 percent and 300 ± 15°F (149 ± 8°C) and with the system gain and discriminator settings fixed at the value which initially permits 1 count per second gamma background, the signal pulse counting rate for a fixed neutron source shall not vary by more than ±5 percent during a test period of 100 hours.

3.2.5 Operating Voltage. The operating voltage shall be as specified in the Ordering Data and shall not exceed 2800 Vdc.

3.2.6 Counting Rate Versus Voltage (Plateau) Characteristics. At room temperature and in the absence of a gamma field, the detector shall exhibit a plateau region in the counting rate versus voltage characteristic. This plateau shall have a minimum length of 300 Vdc with an average slope of 2 percent or less per 100 V. The operating voltage (3.2.5) shall be on the plateau and at least 100 V from either end.
Note: The plateau is not used to select the operating voltage for this standard since it may be required that a number of detectors operate at the same voltage and their characteristics must satisfy this standard at that voltage.

3.2.7 Operating Life. The normal operating life of the detector shall be at least 1 year under the environmental conditions listed in 3.3.

3.3 Environmental Conditions. The detector shall be designed and fabricated to operate under the following environmental conditions.

3.3.1 Temperature Conditions. Temperature conditions vary between 120 to \(150^\circ F\) (49 to \(66^\circ C\)) for normal operation. The design temperature condition shall be \(300^\circ F\) (149\(^\circ C\)) for periods not exceeding 90 days during the one-year lifetime.

3.3.2 Gamma Flux. The gamma flux environment is equal to or less than \(10^3\) R/hr.

3.3.3 External Pressure. The detector shall be required to withstand an external pressure of 10 psig (69 kPa).

3.4 Materials.

3.4.1 Electrodes. The electrode material shall be as specified in the Ordering Data.

3.4.2 Case or Outside Container. The case or outside container material shall be as specified in the Ordering Data.

3.4.3 Connector Shell. The connector shell shall be silver-plated brass.

3.4.4 Insulators. Ceramic insulators shall be in accordance with RDT C 18-1, as specified in the Ordering Data, or both.

3.4.5 Fill Gas. The fill gas shall consist of enriched BF\(_3\) at 70 cm Hg (93 kPa) pressure. The boron-10 enrichment shall be at least 96 percent.

3.5 Mechanical Requirements. The following requirements apply to the detector.

3.5.1 Diameter. The diameter shall be as specified in the Ordering Data.

3.5.2 Length. The length shall be as specified in the Ordering Data.
3.5.3 Connectors. The detector shall have HN jack-type connectors.

3.5.4 Markings. The detector shall be permanently marked on its outer surface using an electrochemical etch. The information shall include the following items:

1. Name of manufacturer.
2. Type number.
3. Serial number.
4. Detector type (BF$_3$ proportional counter).
5. Boron-10 enrichment (percent).
6. Gas pressure.
7. Date of manufacture (month/year).

3.6 Electrical Requirements.

3.6.1 Resistance. The room temperature ($\sim 75^\circ$F [$\sim 24^\circ$C]) insulation resistance from the signal electrode to the case with 3000 Vdc applied shall be equal to or greater than $10^{11}$ ohms.

3.6.2 Capacitance. The room temperature ($\sim 75^\circ$F [$\sim 24^\circ$C]) capacitance from the signal electrode to the case shall not exceed 10 pF at 1 kHz.

3.6.3 Maximum Voltage. The detector shall be able to withstand an applied voltage of 3000 Vdc without breakdown.

3.7 Documentation Requirements.

3.7.1 Test Report. A formal test report shall be provided for review and acceptance prior to the delivery of the detector. The test report shall include, but not be limited to, the following:

1. A detector data sheet listing pertinent characteristics.
2. Material certifications and chemical analyses. This shall include an analysis of the detector fill gas.
3. Outline or assembly drawings of the detector.
4. The complete results of the detector tests or detector and cable tests if integral cables are specified in 3.1.
5. A complete list and description of test equipment and facilities used.
6. An evaluation of test results and recommendations for additional tests or changes in the test procedures.
3.8 Cleaning. The fabrication of a part, combination of parts, subassembly, or assembly shall be conducted to facilitate cleaning, and inspection to minimize contamination. Shop practices and restrictions on the use of materials shall be in accordance with RDT F 5-1. Other appropriate instructions and restrictions that will be used for cleaning during fabrication as well as other documents defining acceptance shop practices, shall be forwarded within the time period specified in the Ordering Data, following the award of contract. These procedures and other documents shall conform to the requirements of RDT F 5-1.

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Quality Verification Program. A quality verification program shall be established and maintained in accordance with RDT F 2-4 and any optional requirements of RDT F 2-4 specified in the Ordering Data.

4.2 Material Certification. A certification shall be provided to certify that all materials used in the detector conform to the standards and specifications invoked in this standard or as specified in the Ordering Data. Where materials are not covered by this standard, the certification of material composition shall be submitted for written approval.

4.2.1 Alternate Materials. Materials other than those specified in this standard or the Ordering Data may be recommended and submitted for approval.

4.3 Inspection. The supplier shall be responsible for the performance of all inspection requirements specified herein. The supplier may utilize his own facilities or any commercial laboratory acceptable to the purchaser. The purchaser shall reserve the right to perform or witness any inspections set forth in this standard or referenced standards. This in no way releases the supplier of his responsibility to furnish equipment and services as specified herein.

4.4 Tests. Unless otherwise specified in the Ordering Data, the tests described in 4.4.2.1, 4.4.2.2, 4.4.3.1, and 4.4.3.5 shall be classified as acceptance tests and the remaining tests described in 4.4.3 and 4.4.4 shall be classified as qualification tests. Acceptance tests shall be performed on each detector to be delivered. Qualification tests shall be performed on one detector selected at random from the production lot. Certified test reports shall be submitted to the purchaser as specified in the Ordering Data. Sample test reports are given in Appendix A.

4.4.1 Test Instruments. The instruments used to perform the tests shall be recorded on the test report forms and shall have an absolute accuracy equal to or better than those listed below. Test instruments shall be adjusted and calibrated in accordance with RDT F 3-2. Suggested test instruments are as follows.
4.4.1.1 D-C Voltmeter. A d-c voltmeter shall be used, in conjunction with a picoammeter, to determine the detector insulation resistance. The measurement accuracy shall be at least ±10 percent of the reading.

4.4.1.2 D-C Picoammeter. A d-c picoammeter with a measurement accuracy of ±10 percent of the reading shall be used with the voltmeter specified in 4.4.1.1 to determine the insulation resistance.

4.4.1.3 Capacitance Bridge. A capacitance bridge shall be used to measure the detector and cable capacitance. The accuracy shall be at least ±5 percent with operation at 1000 Hz.

4.4.1.4 High Voltage Power Supply. A high voltage power supply capable of providing a variable voltage in the range of 0 to 3000 Vdc shall be required.

4.4.1.5 Counting Equipment. A complete nuclear counting system is used to determine the integral bias counting characteristics. The system used shall have less than 10 percent total counting loss at 10^5 counts per second, exclusive of the detector. The following components shall be used:

1. A charge-sensitive preamplifier with 30 feet (9.1 m) of RG 225/U cable connecting it to the detector (unless integral cables have been specified, in which case they shall be used). The conversion gain, rise time and pulse shaping characteristics under operational conditions shall be recorded. The unloaded preamplifier shall have a rise time < 100 nanoseconds.

2. A main amplifier following the preamplifier with suitable gain and pulse shaping characteristics to amplify the pulses to levels suitable for discrimination. If not included in the preamplifier, the amplifier shall have clipping time constants of 1 microsecond and 100 nanoseconds for use in different tests.

3. An integral discriminator calibrated in 0 to 10 units used to obtain the integral bias characteristic. The discriminator input shall be compatible with the output of the main amplifier.

4. A timer/scaler used to obtain counting data.

5. A pulse generator with a rise time less than 0.5 microsecond used to check the system gain.
4.4.1.6 Temperature Sensors. Temperature sensors shall be used to measure the detector and cable temperatures. They shall have an accuracy of ±4°F (±2°C) or better, between 70 and 400°F (21 and 204°C).

4.4.1.7 Other Test Equipment.

1. Neutron source. A calibrated neutron source is required to produce an equivalent thermal neutron flux of between $10^2$ and $10^3$ n/s.

2. Gamma source. A gamma source is required which is capable of producing a calibrated gamma flux of $1 \times 10^3$ R/hr incident onto the detector.

3. Combined neutron and gamma sources. A facility is required which produces $1 \times 10^3$ R/hr gamma flux and from $10^2$ to $10^3$ n/s thermal neutron flux. The facility utilized may employ either air or water as the test environment. For this facility, it must be possible to remove the neutron source to permit gamma testing only. These requirements may be fulfilled by the test facilities listed in items 1 and 2 above if a combination of those sources is possible.

4.4.2 Impedance Tests.

4.4.2.1 Detector Insulation Resistance Tests.

a. The insulation resistance shall be determined by the voltage to amperage (V/I) ratio method using a voltmeter and an picoammetter. The picoammetter shall be connected in series with the detector and a voltage supply capable of providing 3000 Vdc. The voltage shall be measured at the output of the power supply and together with the measured current used to compute the insulation resistance. If integral cables have been specified in the 3.1, this test will be a combined detector/cable test.

b. If detachable cables are employed, the cable insulation resistance shall be measured separately using the equipment and voltages as described in (a).

c. The data shall be certified on a test report certificate (Appendix A).

4.4.2.2 Detector Capacitance.

a. Room temperature capacitance between the center electrode and the case shall be measured. If detachable cables are used, their capacitance shall be measured and subtracted.
4.4.3 Detector Integral Bias Characteristics and Neutron Sensitivity Tests. Recording of the integral pulse spectra for a neutron detector represents an important characterization of its performance; however, the data obtained can be strongly dependent upon the attached cables, electronics and operating conditions. Any or all of these parameters may be specified in the Ordering Data. Whether specified or by manufacturers' choice, all parameters shall be accurately documented and included with the characteristics.

References to detector sensitivity throughout this section shall be based on a background counting rate from all causes of 1 count per second. The neutron sensitivity shall be determined by dividing the observed counting rate at the 1 count per second background discrimination level by the incident neutron flux.

With the operating voltage specified in 3.2.5, the system gain shall be set and measured with the cables attached that will be used in the test (4.4.1.5, Item 1). The test pulse shall be applied through the normal detector cables and its position recorded on the integral bias curve for the detector.

4.4.3.1 Neutron Count Rate Versus Voltage Characteristic (Plateau Curve).

a. Gain adjustment. With the detector exposed to the specified neutron source, the detector voltage adjusted to the maximum operating voltage (3.2.5), and the pulse shaping time constant set for 1 microsecond, adjust the amplifier and preamplifier gain to the maximum values that will not cause amplifier overloading due to the resulting neutron pulses. Record the values of the preamplifier and amplifier gain. Then apply a test pulse from a precision pulse generator through a calibrated 1 pF charge transfer capacitor into the input of the detector cable. With the discriminator set at a known value, measure the voltage amplitude from the pulse generator that will give a counting rate (± 10 percent) equal to one-half of the pulse generator rate. From this measurement, determine the charge sensitivity of the system for the above gain and discriminator settings. Record this value.

b. With the system parameters as adjusted in (a) above, place the detector in the specified neutron source and determine the counting rate versus applied voltage characteristic for the detector at 50 V increments over the range from about 1500 Vdc to 3000 Vdc. Plot the data on the test report certificate (Appendix A).

c. If the plateau characteristics so determined satisfies the requirements of 3.2.6, this requirement has been fulfilled.
4.4.3.2 Background Integral Bias Characteristics at Room Temperature.

a. The detector shall be placed in a neutron-free environment at the system conditions determined in 4.4.3.1. The operating voltage shall be as specified in 3.2.5.

b. Data for the background integral bias curve shall be taken at ten approximately equidistant bias voltage settings between those which produce 5 and $1 \times 10^5$ counts per second. The 1 count per second discriminator value shall be determined by extrapolating the lower straight portion of the background curve between 5000 counts per second and 5 counts per second until it crosses the 1 count per second ordinate. The count rate shall be determined by either a count rate meter (CRM) or a timer/scaler. If a count rate meter is used, it shall be calibrated at two count rate values within each decade using a timer/scaler and each CRM decade shall be accurate to ±2 percent of equivalent full-scale linear value for the decade.

c. A curve shall be plotted with discriminator units as the abscissa on a linear scale and count rate as the ordinate of a five-cycle logarithmic scale.

d. The test report certificate (Appendix A) shall be completed and certified.

4.4.3.3 Neutron Integral Bias Characteristics at Room Temperature.

a. The detector/cable assembly shall be placed in a calibrated thermal neutron flux of $10^2$ to $10^3$ n/s at the detector, as determined by activation techniques or other approved calibration methods.

b. The excitation voltage shall be the same as used in 4.4.3.2. This voltage shall be measured on the detector side of all added filter circuit resistance with corrections made for voltage drop in the filter resistance from the meter current.

c. Data for the neutron integral bias curve shall be taken with at least 20 steps spaced so that the shape of the curve can be accurately determined. The counting rate shall be determined as required by 4.4.3.2.

d. The data shall be plotted on the same curves as the data for 4.4.3.2.

e. The neutron sensitivity shall be calculated as the ratio of the neutron counting rate at the discriminator setting which produces 1 count per second background counting rate to the perturbed neutron flux at the detector. Record the value on the test report certificate (Appendix A).
4.4.3.4 Gamma Integral Bias Characteristics at Room Ambient Temperature. This section and 4.4.3.5 establish the neutron counting sensitivity at a rated gamma flux of $10^3$ R/hr. Establishing the best possible sensitivity at these flux levels requires the use of considerably faster pulse shaping time constants than those used for previous tests. For these tests and those in 4.4.3.5, the pulse shaping time constants shall be adjusted to 100 nanoseconds. Since the fast shaping will significantly attenuate the signal amplitude, it will be necessary to increase the system gain. The gain shall be readjusted to the maximum value that will not cause amplifier overloading with either neutrons alone or the combined neutron plus gamma ($10^3$ R/hr) incident on the detector. This gain determination shall be recorded on the data sheet.

a. The detector shall be placed in a calibrated gamma flux of $1 \times 10^3$ R/hr at the detector location. The actual value shall be recorded on the data sheet.

b. System parameters shall be adjusted as described above. The actual applied voltage shall remain the same as for 4.4.3.2.

c. Integral bias curve data shall be obtained as described in 4.4.3.2.

d. The data shall be plotted on a new graph in the manner described in 4.4.3.2.

e. The test report certificate (Appendix A) shall be completed and certified.

4.4.3.5 Neutron Integral Bias Curve at $1 \times 10^3$ R/hr.

a. With the detector in the same gamma flux as required for the tests of 4.4.3.4, a neutron source producing a known and calibrated flux shall be installed in the test. Record the neutron flux value on the test report certificate (Appendix A).

b. The system parameters and detector bias voltage shall remain the same as for 4.4.3.4. Data for the neutron integral bias curve shall be taken as required by 4.4.3.3. This data shall be plotted on the same curve as the data from 4.4.3.4.

c. The neutron sensitivity at $1 \times 10^3$ R/hr gamma shall be calculated as the ratio of the neutron counting rate at the same discriminator setting which produces 1 count per second from gamma caused pileup pulses, to the neutron flux at the detector. Record the value on the test report certificate (Appendix A).
4.4.3.6 Integral Bias Curves and Plateau Characteristics at Rated Temperatures.

a. The detector shall be heated to the 300°F (149°C) maximum rated operating temperature. Tests required by 4.4.3.1 through 4.4.3.3 shall be repeated at this temperature with all other conditions and system parameters the same as those used in the respective room temperature tests.

b. These data shall be plotted together on a graph separate from but identical to the room temperature data.

c. The test report certificate (Appendix A) shall be completed and certified.

4.4.4 Sensitivity Variation with Time. The detector shall be placed in a location having a thermal neutron field of $10^2$ to $10^3$ nV, a $1 \times 10^3$ R/hr gamma field, and shall be heated to the rated temperature (3.3.1). The operating system parameters shall be set as required by 4.4.3.4.

With the entire system left in this configuration, a neutron-caused count rate shall be obtained on a daily schedule for a period of 100 hours. This counting rate shall not vary more than ±5 percent during the test. The counting rate determination shall be made with an accuracy of at least ±1 percent. This generally requires the use of a timer/scaler. The data shall be recorded and certified on the test report certificate (Appendix A).

5. PREPARATION FOR DELIVERY

5.1 Packaging, Packing, and Marking. Packaging, packing, and marking shall be accordance with RDT F 7-2 and as specified in the Ordering Data.

5.2 Shipping Requirements. The shipping container design shall provide protection against damage caused by dropping of tools, stepping on the detector tubes, and similar accidents during shipment, storage, and installation.

5.2.1 Marking. All shipping containers shall be clearly marked in many locations as necessary for legibility with signs of contrasting colors and of suitable composition with the following statement: "Fragile-Delicate Instrument".

5.2.2 Shipping. The supplier shall be responsible for shipping the detector. Handling equipment and shipping containers shall be adequate to prevent damage from handling and shipping shock and vibration.
5.2.3 Supports. Required shipping position, supports, and crating shall be determined by the supplier.

5.2.4 Storage. The detector may be stored for significant periods of time prior to installation and use. The packing, packaging, and marking shall be designed accordingly. As a minimum the package shall:

1. Maintain cleanliness requirements of this standard.
2. Provide access for periodic inspection.
3. Provide instructions necessary to maintain storage conditions.

5.2.5 Contamination. Contamination during storage at the manufacturing facility, or during shipping of the detector shall be prevented. Contamination by lead, zinc, sulfur, mercury, phosphorous, and halide contaminants shall be limited to a total no greater than 50 ppm. No contact with materials or tools that might cause contamination shall be permitted.

6. NOTES AND ORDERING DATA CHECKLIST

6.1 Ordering Data Checklist. The following technical and procurement data will be furnished by the purchaser. Any necessary data not furnished with the purchase document shall be requested from the purchaser before submitting a bid.

<table>
<thead>
<tr>
<th>Item</th>
<th>Refer to Paragraph</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Drawings and other documents</td>
<td>2.2</td>
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<td>2. General</td>
<td>3.1</td>
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<tr>
<td>3. Operating voltage</td>
<td>3.2.5</td>
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<tr>
<td>4. Electrodes</td>
<td>3.4.1</td>
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<tr>
<td>5. Case or outside container</td>
<td>3.4.2</td>
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<tr>
<td>6. Insulators</td>
<td>3.4.4</td>
</tr>
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<td>7. Diameter</td>
<td>3.5.1</td>
</tr>
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<td>8. Length</td>
<td>3.5.2</td>
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<td>9. Cleaning</td>
<td>3.8</td>
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<tr>
<td>10. Quality verification program</td>
<td>4.1</td>
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<td>11. Alternate materials</td>
<td>4.2.1</td>
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<tr>
<td>12. Tests</td>
<td>4.4</td>
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<tr>
<td>13. Detector integral bias characteristics and neutron sensitivity tests</td>
<td>4.4.3</td>
</tr>
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<td>14. Background integral bias characteristics at room temperature</td>
<td>4.4.3.2</td>
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<tr>
<td>15. Packaging, packing, and marking</td>
<td>5.1</td>
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</table>
APPENDIX A

TEST REPORT CERTIFICATES
FOR
BF$_3$ PROPORTIONAL COUNTER

Manufacturer ____________________________

Type No. ____________________________ Serial No. ____________________________

TEST EQUIPMENT USED FOR TEST REPORTS 1 to 5

A. Voltmeter. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________
   Claimed Accuracy ____________________________
   Last Calibrated on ____________________________ Calib. Due on ____________________________

B. Picoammeter. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________
   Claimed Accuracy ____________________________
   Last Calibrated on ____________________________ Calib. Due on ____________________________

C. Capacitance Bridge. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________
   Claimed Accuracy ____________________________
   Last Calibrated on ____________________________ Calib. Due on ____________________________

Oscillator. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________

Null Detector. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________

D. High Voltage Supply. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________

E. Counting Equipment.
   Preamplifier. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________
   Amplifier. Manufacturer ____________________________
   Model No. ____________________________ Serial No. ____________________________
Discriminator. Manufacturer ________________________________  
Model No. ________________________________ Serial No. ____________

Time/Scaler. Manufacturer ________________________________  
Model No. ________________________________ Serial No. ____________

Pulse Generator. Manufacturer ________________________________  
Model No. ________________________________ Serial No. ____________

Last Calibrated on _________________ Calib. Due on ______________

F. Other Equipment Used (Listed as Above).

Certified by ___________________________ Date ____________
A.1 Test 1 - IMPEDANCE TEST (4.4.2)

Date Test Performed
Room Ambient Temperature
Rated Temperature
Equipment Used

INSULATION RESISTANCE AT 3000V

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Measured Current</th>
<th>Measured Voltage</th>
<th>Computed V/I</th>
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<tr>
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<td></td>
<td></td>
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<tr>
<td>Cable</td>
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</table>

Certified by ______________________ Date __________

ROOM TEMPERATURE CAPACITANCE MEASUREMENT

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<tr>
<th>Test Item</th>
<th>Capacitance - pF</th>
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<tbody>
<tr>
<td>Detector/Cable</td>
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</tr>
<tr>
<td>Cable Detector</td>
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</tr>
</tbody>
</table>

Note: Cable capacitance must be subtracted from the combined detector/cable capacitance providing detachable cables are used.

Certified by ______________________ Date __________
A.4 Test 4 - COMBINED INTEGRAL BIAS CHARACTERISTIC RESULTS
(4.4.3.4, 4.4.3.5)

Date Tests Performed ________________________________

Excitation Voltage ________________________________ volts

Amplifier Gain Settings ______________________________

Pulse Shaping Time Constants \( \tau_I \quad \tau_{D_1} \quad \tau_{D_2} \) __________________________

INTEGRAL BIAS CURVE DATA

<table>
<thead>
<tr>
<th>Type of Source and Facility</th>
<th>Discriminator Setting</th>
<th>Count Rate</th>
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</thead>
<tbody>
<tr>
<td>( 10^3 ) R/hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( ^{60}Co - \gamma )</td>
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<td>Facility</td>
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<td>( 10^3 ) ( \text{nv} )</td>
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<td>Pu-Be</td>
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<tr>
<td>Source Gold Foil Calibration</td>
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The data above shall be used to construct a graph showing the gamma only and neutron plus gamma characteristics at \( 1 \times 10^3 \) R/hr for the detector. The neutron sensitivity at \( 1 \times 10^3 \) R/hr shall be calculated from values obtained from these characteristics and recorded below. Curves shall be plotted on 5-cycle semilog paper.

Neutron sensitivity at \( 10^3 \) R/hr with discriminator adjusted for 1 count per second gamma background counting rate ________________________.

Certified by ______________________ Date __________
A.5 Test 5 - SENSITIVITY VARIATION WITH TIME (4.4.4)

Amplifier Gain Settings

Pulse Shaping Time Constants

Discriminator Setting for 1 Count per second Gamma Background

Neutron Flux \( \text{nv} \)

Gamma Flux \( \text{R/hr} \)

Temperature \( ^\circ\text{F} \)

Operating Voltage

**COUNTING DATA**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Counting Rate*</th>
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*Note: This counting rate must be taken with the system parameters as listed above.

Calculated counting rate variation during test period

Certified by _____________________ Date ________