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# High-Temperature and High-Humidity Response of the Eberline Model PRS-2 and the Eberline Model NRD Neutron Detector

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# HIGH-TEMPERATURE AND HIGH-HUMIDITY RESPONSE OF THE EBERLINE MODEL PRS-2 AND THE EBERLINE MODEL NRD NEUTRON DETECTOR

by

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## ABSTRACT

The high-humidity and high-temperature response of the Eberline Model PRS-2 portable scaler-ratemeter and the Eberline Model NRD neutron detector was studied in an environmental chamber. The $BF_3$ probe used in the NRD detector was found to produce count rate surges at temperatures >50°C and at relative humidity >50%. The PRS-2 scaler-ratemeter was found to be relatively insensitive to high temperatures and high humidity.

## I. INTRODUCTION

Experiments were conducted to determine the high-humidity and high-temperature response of the Eberline Model PRS-2 portable scaler-ratemeter and the Eberline Model NRD neutron detector. Tests of both components together, of the PRS-2 alone, and of the neutron detector alone were carried out in an environmental chamber in which the temperature and the relative humidity (RH) were closely controlled.

## II. PROCEDURE

The complete instrument, consisting of the PRS-2 portable scaler-ratemeter and the NRD polyethylene-moderated $BF_3$ neutron detector, was placed in the environmental chamber. The output signal from the PRS-2 amplifier circuit was connected to an external scaler and oscilloscope that monitored the neutron detector's operation. With the temperature held constant at 25°C, the RH was slowly increased from 10 to 90% in 10% increments. The RH remained at each setting for 2 h to allow the instrument to equilibrate to chamber conditions. Count rate increased when the RH was >50%.

Next, the RH was held constant at 25%, and the temperature was increased in 10°C increments from 10 to 60°C, allowing 2 h at each setting for equilibrium to be reached. The count rate increased at temperatures >50°C.

To determine if these RH and temperature effects were synergistic, the temperature was set at 40°C and the RH was set at 40%. After 2 h, no count rate increase was observed.

Then the PRS-2 scaler-ratemeter was placed outside the environmental chamber while the neutron detector remained inside. In this case, the 25.4 cm polyethylene sphere was removed from the $BF_3$ probe to decrease the time required to reach equilibrium. The previous experiments, in which RH and temperature in the test chamber were independently increased, were repeated with similar results. In these tests, each setting was held for only 90 min.

Finally, with the NRD detector located outside the chamber, the PRS-2 was tested for high-humidity and high-temperature response. Under these conditions, the PRS-2 scaler-ratemeter was subjected to 20°C and 90% RH for 90 min, 50°C and 70% RH for 90 min, and 50°C and 90% RH for 15 min. A count rate increase was observed only in the last case.

## III. RESULTS

Tables I and II show the results of the RH and temperature tests in the environmental chamber on the PRS-2 and the NRD detector. Count rates increased when either the RH was >50% or the temperature was >50°C. Count rate increases were not continuous except at greater than about 85% RH. Rather, they appeared as periodic surges lasting approximately 1-5 min and spaced approximately 2-15 min apart. The surges seemed closer together, lasted longer, and were more intense with higher temperatures or higher humidity; however, no predictable response pattern either in terms of total counts or timing of the surges was ascertained. Counting ceased when the $BF_3$ probe was removed from the cable during the surge but would restart when the probe was reattached.

When temperature and RH were maintained slightly below the critical values of 50°C and 50% RH, no increased count rate was observed.

Tables III and IV show results obtained when RH and temperature were increased with only the $BF_3$ detector present in the environmental chamber. Results were almost the same as those obtained when the complete instrument was in the test chamber. Again, the increased count rate appeared in surges rather than being constant.

The PRS-2 scaler-ratemeter was very resistant to heat and RH. When placed alone in the test chamber with the $BF_3$ probe outside, no discharge effects were observed after 90 min at either 20°C and 90% RH or 50°C and 70% RH. Continuous discharge did occur after approximately 15 min at 50°C and 90% RH. This discharge continued even when the detector cable was disconnected from the instrument, but it ceased when the electronics package was removed from the metal case with its detector attachment.

## IV. CONCLUSIONS

We concluded that the $BF_3$ neutron probe used in the Eberline Model NRD detector is sensitive to temperatures >50°C and to RH >50%. Except at RH >85%, this sensitivity resulted in count rate surges rather than stable count rate increases. This behavior is typical of high-voltage "creep" where an electronic charge migrates slowly through an insulator and then dissipates quickly while producing the count rate surge. At >85% RH, the instrument discharged continuously, exhibiting an extremely high and relatively constant count rate.

Breakdown of the $BF_3$ detector appeared to be localized in the detector rather than in the connecting cable because the discharge ceased when the cable was disconnected. Because the probe is hermetically sealed, the breakdown caused by high humidity most likely is due to failure of the exposed cable connector. Reasons for the discharge at high temperature are not understood.

We did not find the detector's response to RH and temperature to be synergistic. If both parameters were held just below the critical points, the instrument continued to operate satisfactorily.

The PRS-2 scaler-ratemeter was unresponsive to RH and temperature except at RH >90%.

TABLE I

OPERATIONAL PERFORMANCE OF PRS-2/NRD AT VARIOUS RH AND AT CONSTANT 25°C

| RH (%) | Operational Performance |
|---|---|
| 20 | Satisfactory |
| 30 | Satisfactory |
| 40 | Satisfactory |
| 50 | Periodic discharge |
| 60 | Periodic discharge |
| 70 | Periodic discharge |
| 80 | Periodic discharge |
| 85 | Continuous discharge |

TABLE II

OPERATIONAL PERFORMANCE OF PRS-2/NRD AT VARIOUS TEMPERATURES AND AT CONSTANT 25% RH

| Temp (°C) | Operational Performance |
|---|---|
| 10 | Satisfactory |
| 20 | Satisfactory |
| 30 | Satisfactory |
| 40 | Satisfactory |
| 50 | Periodic discharge |
| 60 | Periodic discharge |

TABLE III

OPERATIONAL PERFORMANCE OF $BF_3$ NEUTRON DETECTOR AT VARIOUS RH AND AT CONSTANT 25°C

| RH (%) | Operational Performance |
|---|---|
| 20 | Satisfactory |
| 30 | Satisfactory |
| 40 | Satisfactory |
| 50 | Satisfactory |
| 60 | Periodic discharge |
| 70 | Periodic discharge |
| 80 | Continuous discharge |
| 90 | Continuous discharge |

TABLE IV

OPERATIONAL PERFORMANCE OF $BF_3$ NEUTRON DETECTOR AT VARIOUS TEMPERATURES AND AT CONSTANT 25% RH

| Temp (°C) | Operational Performance |
|---|---|
| 10 | Satisfactory |
| 20 | Satisfactory |
| 30 | Satisfactory |
| 40 | Satisfactory |
| 50 | Periodic discharge |
| 60 | Periodic discharge |