Cobalt Source Calibration

by

H. M. Rizvi

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

DOE Contract No. **DE-AC09-96SR18500**

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

COBALT SOURCE CALIBRATION

H. M. Rizvi

October 5, 1999

Westinghouse
Savannah River Company
Aiken, SC 29808


COBALT SOURCE CALIBRATION

Author

M. J. Barnes for H. M. Rizvi 10/5/99
H. M. Rizvi, Waste Processing Technology Date

Design Check

M. J. Barnes 10/5/99
M. J. Barnes, Waste Processing Technology Date

Approvals/Review

Samuel D. Fink 10/5/99
S. D. Fink, Level 4 Manager, Waste Processing Technology Date

Darrel D. Walker 10/5/99
D. D. Walker, Waste Processing Technology Date

1.0 Summary

The data obtained from these tests determine the dose rate of the two cobalt sources in SRTC. Building 774-A houses one of these sources while the other resides in room C-067 of Building 773-A. The data from this experiment shows the following.

- The dose rate of the #2 cobalt source in Building 774-A measured 1.073×10^5 rad/h (June 17, 1999). The dose rate of the Shepherd Model 109 Gamma cobalt source in Building 773-A measured 9.27×10^5 rad/h (June 25, 1999). These rates come from placing the graduated cylinder containing the dosimeter solution in the center of the irradiation chamber.

- Two calibration tests in the 774-A source placed the graduated cylinder with the dosimeter solution approximately 1.5 inches off center in the axial direction. This movement of the sample reduced the measured dose rate 0.92% from 1.083×10^5 rad/h to 1.073×10^5 rad/h.

- A similar test in the cobalt source in 773-A placed the graduated cylinder approximately 2.0 inches off center in the axial direction. This change in position reduced the measured dose rate by 10.34% from 1.036×10^6 to 9.27×10^5.

2.0 Introduction

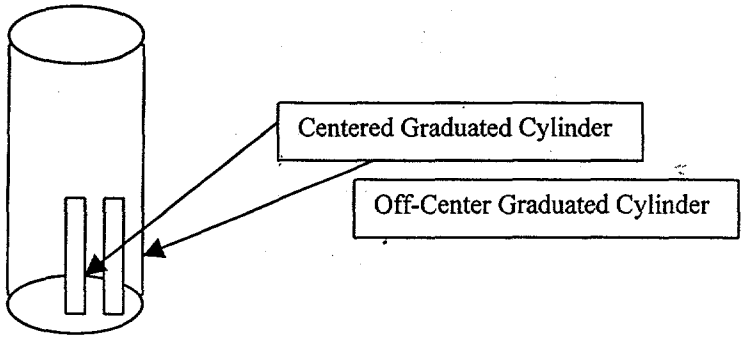
This testing used chemical dosimetry to measure the dose rate of a radioactive source. In this method, one determines the dose by the chemical change that takes place in the dosimeter. For this calibration experiment, I used a Fricke (ferrous ammonium sulfate) dosimeter. This solution works well for dose rates to 10^7 rad/h.[1] During irradiation of the Fricke dosimeter solution the Fe^{2+} ions ionize to Fe^{3+}. When this occurs, the solution acquires a slightly darker tint (not visible to the human eye). To determine the magnitude of the change in Fe ions, one places the solution in an UV-VIS Spectrophotometer. The UV-VIS Spectrophotometer measures the absorbency of the solution. Dividing the absorbency by the total time (in minutes) of exposure yields the dose rate.

3.0 Experimentation

This experiment calibrated two cobalt sources: the #2 source in Building 774-A, and the Shepherd Model 109 Gamma Source in Building 773-A, Room C-067. For each source, the test included two different dose rate measurements. One measurement centered the quartz graduated cylinder while the other moved the graduated cylinder off-center.

---

[1] Bibler, Ned E. Calibration of Intense Co Gamma Ray Sources at the Savannah River Plant. May 1976. DP-1414.



The off-center, and centered calibrations occurred separately in building 774-A. During calibration, the researcher lowered the quartz-graduated cylinder into the source for 2.5, 5.0, 7.5, and 10.0-minute time periods. Calibration of the centered and off-center graduated cylinder in the source in building 773-A occurred simultaneously. This calibration exposed the graduated cylinders to radiation for approximately 15, 30, 45, and 60-second time periods. After each exposure, the researcher poured the irradiated solution into a labeled glass vial. The researcher then rinsed the graduated cylinders with unirradiated Fricke solution, and refilled with unirradiated Fricke solution for the next measurement. I completed the following tests.

	Experiments	Comments
1	Calibration of 774-A Source Centered	
2	Calibration of 774-A Source Centered	Replicate of #1
3	Calibration of 774-A Source Uncentered	
4	Calibration of 774-A Source Uncentered	Replicate of #3
5	Calibration of 773-A Source Centered	
6	Calibration of 773-A Source Uncentered	

4.0 Results and Discussion

4.1 Calibration of Source in building 774-A Centered

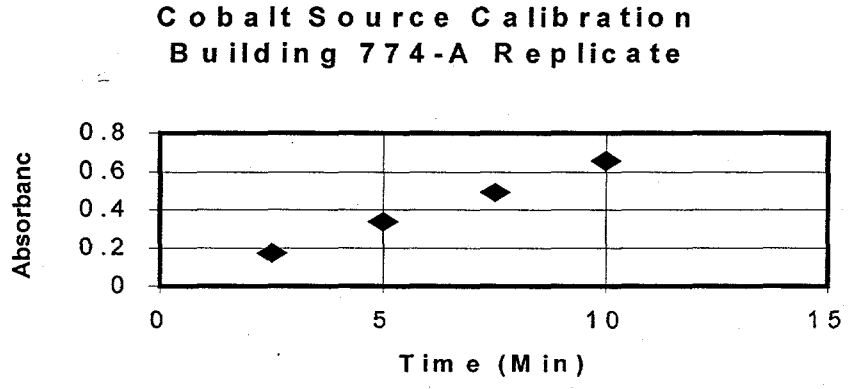
	Time (min)	Fricke Ref.	Position	Temp (°C)	Abs/min	Rad/h
1	2.5	0.176	Off-Center	28.2	0.0704	1.183E+05
2	5.0	0.348	Off-Center	28.7	0.0696	1.169E+05
3	7.5	0.491	Off-Center	27.7	0.0655	1.100E+05
4	10.0	0.650	Off-Center	26.6	0.0650	1.092E+05

R-Square: 0.99883
Dose Rate: 1.052×10^5 rad/h

In this experiment, the data appears linear, but with an R-Square value lower than expected. As a result, I repeated the experiment. The data yields a dose rate of 1.052 x 10^5 rad/h.

4.2 Calibration of 774-A Source Centered Replicate

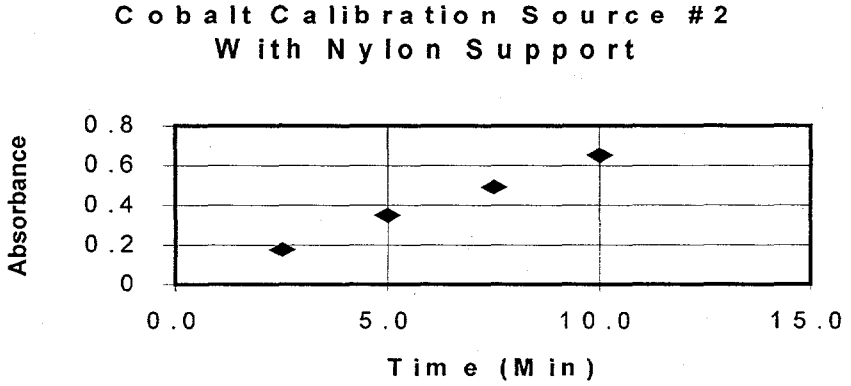
	Fricke Ref.	Temp (°C)	Position	Time (min)	Abs/min	Rad/h
1	0.173	25.7	Center	2.5	0.0692	1.163E+05
2	0.339	26.2	Center	5.0	0.0678	1.139E+05
3	0.490	25.4	Center	7.5	0.065333	1.098E+05
4	0.655	24.0	Center	10.0	0.0655	1.100E+05



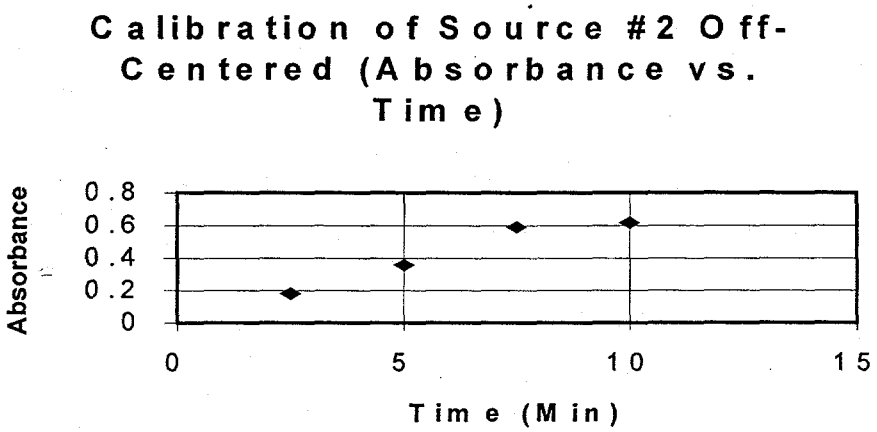
R-Square: 0.999668
Dose Rate: 1.073 x 10^5 rad/h

In this experiment, the data again appears linear but with an R-Square within accepted parameters. (The author judged any value with an R-Square greater than 0.99 as acceptable.) The measurements indicate a dose rate of 1.073 x 10^5 rad/h.

4.3 Calibration of 774-A Source Off-Center



	Time	Water R.	Fricke R.	Temp (°C)	Position	Abs	Abs/min	Rad/h
Fricke	n/a	0.01	n/a	n/a	n/a	n/a	n/a	n/a
1	2.5	n/a	0.180	26.0	Off-Center	0.180	0.072	1.210E+05
2	5.0	n/a	0.358	25.9	Off-Center	0.358	0.072	1.203E+05
3	7.5	n/a	0.590	25.3	Off-Center	0.590	0.079	1.322E+05
4	10.0	n/a	0.617	26.9	Off-Center	0.617	0.062	1.037E+05

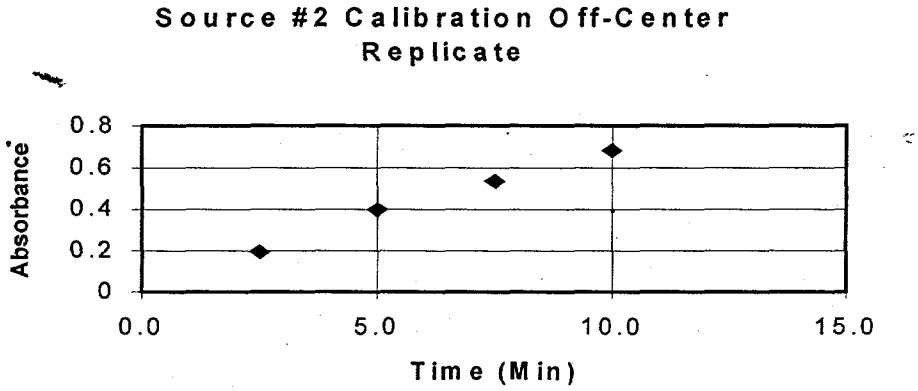


Dose Rate: 1.037 x 10^5 rad/h
R-Square: 0.9293167

The resulting graph is not linear. The final point on the graph deviates significantly. As a result, the R-Square of this experiment was 0.929, far lower then the acceptable value. The large error may have resulted from the source canister inadvertently revolving as personnel lowered it into the source. The rotation of the canister could have altered the placement of the graduated cylinder relative to the source, and thus affected the dose rate.

4.4 Replicate Calibration of 774-A Source Uncentered

	Time (min)	Fricke Ref.	Position	Temp (°C)	Abs/min	Rad/h
1	2.5	0.194	Off-Center	26.5	0.0776	1.304E+05
2	5.0	0.398	Off-Center	26.4	0.0796	1.337E+05
3	7.5	0.537	Off-Center	26.5	0.0716	1.203E+05
4	10.0	0.685	Off-Center	26.3	0.0685	1.151E+05

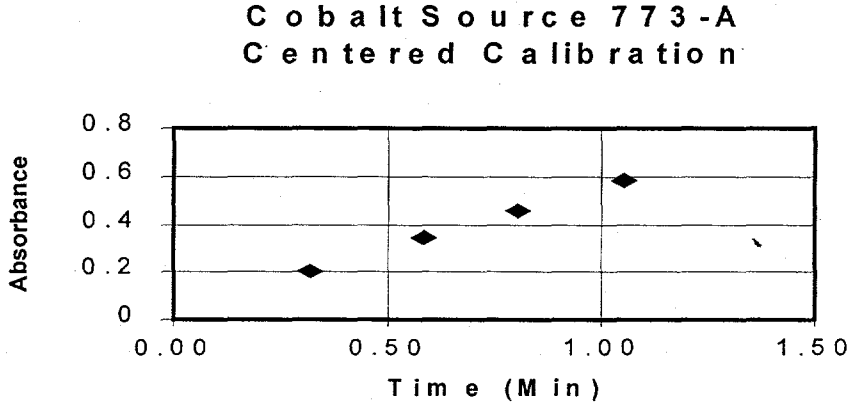


Dose Rate: 1.083 x 10^5 rad/h
R-Square: 0.991924

The R-Square for the repeated experiment proved much larger and I accepted this dose rate as reliable for this configuration.

4.5 Calibration of 773-A Source Centered

	Time (s)	Time (min)	Fricke Ref.	Position	Temp (°C)	Abs/min	Rad/h
1	19	0.32	0.205	Center	27.5	0.647	1.17E+06
2	35	0.58	0.345	Center	27.0	0.591	1.06E+06
3	48	0.80	0.456	Center	26.8	0.570	1.03E+06
4	63	1.05	0.583	Center	27.3	0.555	9.99E+05



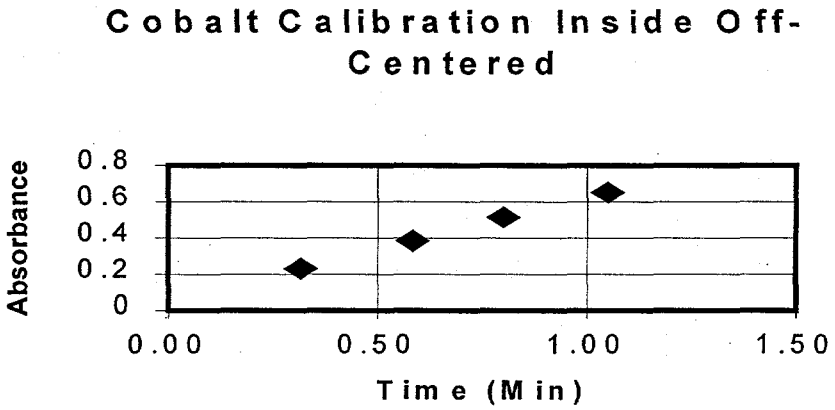
Dose Rate: 9.27 x 10^5 rad/h
R-Square: 0.999935

The high R-Square for this experiment probably results because this cobalt source includes an automated design for lowering the graduated cylinder, rather than the manual design used in building 774-A. This method reduces the

variances in speed for lowering the sample. A variance in speed results in a variance in the time the Dosimeter solution stays within the radiation field.

4.6 Calibration of 773-A Source Off-Center

	Time (s)	Time (min)	Fricke Ref.	Position	Temp (°C)	Abs/min	Rad/h
1	19	0.32	0.232	Off-Center	27.5	0.732632	1.32E+06
2	35	0.58	0.383	Off-Center	27.0	0.656571	1.18E+06
3	48	0.80	0.515	Off-Center	26.8	0.64375	1.16E+06
4	63	1.05	0.651	Off-Center	27.3	0.62	1.12E+06



Dose Rate: 1.034 x 10^6 rad/h
R-Square: 0.999603

The higher dose rate for the Off-Center test suggests a closer position to the cobalt source.

Summary

The data obtained from these Cobalt Source Calibration tests show the following.

- The experiments determined a dose rate of the #2 cobalt source in Building 774-A of 1.073 x 10^5 rad/h (June 17, 1999). The dose rate of the Shepherd Model 109 Gamma cobalt source in Building 773-A measured 9.27 x 10^5 rad/h (June 25, 1999). These rates come from placing the graduated cylinder containing the dosimeter solution in the center of the irradiation chamber.

- Two calibration tests in the 774-A source placed the graduated cylinder with the dosimeter solution off-center approximately 1.5 inches off in the axial direction. This movement of the sample reduced the measured dose rate 0.92% from 1.083 x 10^5 rad/h to 1.073 x 10^5 rad/h.

- A similar test in the cobalt source in 773-A placed the graduated cylinder approximately 2.0 inches off center in the axial direction. This change in position reduced the measured dose rate by 10.34% from 1.036 x 10^6 rad/h to 9.27 x 10^5 rad/h.

- The use of some instrument to keep the calibration canister from rotating while lowering into the 774-A pit would help increase the accuracy of the results.

- The sources decrease in dose rate by a factor of approximately 0.8% every month. Hence, calibrations should occur on a monthly basis.

5.0 Quality Assurance

The procedures, measurement, and results with regard to this experiment are located in WSRC-NB-99-00150 lab notebook.

6.0 Acknowledgements

The author of this document would like to thank the following people who assisted in this experiment: Betty Croy, Lin Thacker, Kimberly Prettel, Charles Crawford, and Darrel D. Walker.

7.0 References

Bibler, Ned E. *Calibration of Intense Co Gamma Ray Sources at the Savannah River Plant*. May 1976.

DISTRIBUTION:

M. J. Barnes, 773-A
Chris Beam, 773-41A
S. D. Fink, 773-A
F. F. Fondeur, 773-A
D. T. Hobbs, 773-A
R. A. Peterson, 773-A
D. D. Walker, 773-A
STI, 703-43A
WPTS Files c/o Cathy Canada, 773-A