Personnel Radiation Dosimeter
Handling and Evaluation Procedures
Revised January 1978

1. Introduction

1.1 The Radiation Control Laboratory, Environmental Quality Control Division, Industrial Relations Department, provides a personnel radiation exposure monitoring service to all Corporation facilities and operations as required. Since January 1, 1971, such monitoring has been accomplished through the use of thermoluminescent dosimetry (TLD).

1.2 Thermoluminescent Dosimetry - TLD is based on the ability of certain materials to store energy absorbed during exposure to ionizing radiation. This occurs when electrons that have been raised to an elevated energy state as the result of radiation exposure are subsequently held in energy "traps" in the crystalline lattice. The number of trapped electrons is proportional to the radiation exposure. When the crystalline material is heated to a sufficiently high temperature, the electrons are released and fall back to their ground state energy and give up the stored energy in the form of light. Radiation exposure can be evaluated by measuring the light release with a photomultiplier tube contained in a properly calibrated read-out instrument.

1.3 Dosimeter Types - Both whole body and extremity monitors are available for gamma, and x-ray radiation. Whole body badges monitor doses to the whole body or a major portion. The extremity badges monitor finger or hand doses. The dosimeters are also capable of detecting thermal neutrons; however, the system has not been calibrated to quantify neutron dose.

2. TLD System

2.1 The TLD system consists of the dosimeters and holders that are worn by the individuals being monitored and the read-out equipment.

2.2 Dosimeters - The dosimeters used are Harshaw TLD-100 for x-ray and gamma radiation. These are natural lithium fluoride pressed chips measuring 1/8 inch by 1/8 inch by 0.035 inches thick. The chips are used in a plastic dosimeter holder (Radiation Detection Company) behind 1/8 inch of polyurethane foam for whole body monitoring. For extremity monitoring, rings manufactured by either NRTS, Radiation Detection Company or Harshaw will be used.

2.3 TLD Read-Out - The exposures recorded by the dosimeters are evaluated by a Harshaw Model 2000 System consisting of a Harshaw Model 2000A Thermoluminescence Detector, a Harshaw Model 2000B Automatic Integrating Picoammeter, and a Varian 5-inch strip chart recorder.

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3. Preparation of Dosimeters

3.1 The dosimeter chips should be clean and exhibit a translucent white color. If cleaning is indicated, immerse the chips in a methanol bath for a few minutes and hand agitate. Remove them from the methanol and let them air dry.

3.2 Before any dosimeters are used, they must be annealed. Place the dosimeters in a clean pyrex beaker and insert into a muffle furnace which has been pre-heated to 752°F (400°C). Anneal for 1 hour. Following the 1 hour anneal, turn the furnace off, open the door slightly and allow the chips to cool to 100°C. Place the dosimeters in a drying oven set at 100°C for 1 hour. Following this treatment, remove the dosimeters and allow them to cool to room temperature in a dark environment.

3.3 Place the cooled annealed dosimeters in the plastic storage container marked "Annealed" and store in a light-tight box unless the dosimeter holders are to be loaded immediately.

4. Dosimeter Handling

4.1 There are sufficient dosimeter chips to monitor approximately twice the number of employees presently being monitored.

4.2 All annealing is to be performed on a batch basis with all dosimeter chips annealed at one time.

4.3 If more than one beaker is used for annealing, the chips are to be consolidated into one container following the low temperature annealing (before cooling to room temperature).

4.4 Once a chip is removed from the "Annealed" storage container, it is not to be returned, even if it is not used.

4.4.1 If a chip is not placed in a badge, then it is to be placed in the container marked "To Be Annealed", following its use.

5. Dosimeter Holder Handling

5.1 Identify each dosimeter holder by the clock symbol and number of the individual to whom it is assigned as well as the facility code.

5.2 Place one annealed chip in a dosimeter holder, insert a foam spacer over the chip and secure with the front cover.

5.3 Prepare for each facility a holder identified with the word "control" containing one annealed chip to accompany each shipment of dosimeter holders.

5.4 Forward instructions with each group of dosimeters regarding the wearing period and other appropriate information.

5.5 Prepare a replacement set of dosimeter holders and send to each facility prior to the expiration of the current wearing period. Each set will have a different color coding for the purpose of identification.

5.6 Start a wearing period with the first day of the month and end with the last day of the month whether or not these days are normal working days.

5.6.1. If the new wearing period begins on a non-working day, the new dosimeters are to be distributed and the current dosimeters collected at the end of the shift on the last working day of the current month.

5.6.2. Where the wearing period begins on a normal working day, the new dosimeters are to be distributed and the current dosimeters collected at the beginning of the shift on the first day of the new month.

6. Initial TLD Reader Warm Up

6.1 Set the meter switch to "zero", the ampere range switch to "auto", the period switch to "30 seconds" and turn on the power switch. Let the unit warm up for at least 2 hours.

6.2 Zero the instrument by turning the meter switch to zero, and setting the ampere toggle switch to X0.1. The meter needle should come to the zero set mark on the meter face. If not, adjust the zero knob as required. Return the ampere toggle switch to X1.

6.3 Open the nitrogen valve. Check the flow meter, it should indicate 4 lpm.

6.4 Set the meter switch to "H.V.". The needle should indicate between 570-610 volts. If not, adjust the vernier high voltage knob as required, then lock the vernier.

6.5 Set the meter switch to current, the period switch to 10 seconds, pull the drawer out to its fully open position and depress the read button.

6.6 The 10 second integrated current should be approximately 20 nanocoulombs. If not, adjust the H.V. vernier until the current reading is obtained.

6.7 Set the meter switch to "current" and the period switch to "30 seconds". On the Model 2000A set the heater temperature indicator to between 6 and the next higher line. T1 & T2 should read 110 and 240 respectively and be locked in place.

6.8 Close the drawer, allow a few seconds for the dark current to stabilize. It should stabilize at 1 to 2 on the meter. If not, adjust the current suppression knob on the back of the Model 2000B.

6.9 Depress the read button. The reading should be approximately _____ nanocoulombs. If not, adjust the current suppression until the desired reading is obtained. The system is now ready for initial calibration.

7. Initial Calibration

7.1 Make sure the system is set as follows:

2000A -	Heater temperature	- between 6 and next line.
	T1/T2	- 110/240
2000B -	High Voltage	- set for 10 seconds open drawer reading of 20 nanocoulombs.
	Period	- 30 seconds
	Meter	- Current
	Range Ampere	- Auto
	Toggle Switch	- X1
	Current Suppression	- Set for 30 second blank drawer reading of _____ nanocoulombs
	Zero	- Zero set mark.
	Nitrogen Gas	- 4 lpm

7.2 Using the vacuum handler, place an annealed chip in the depression of the heating pan. Make sure the temperature of the pan is below 100°C. Close the drawer carefully so that the chip position does not shift. Allow the dark current to stabilize between 1-2, then depress the read button. The read light will indicate the cycle has started.

7.3 When the read cycle is finished, record the reading in nanocoulombs. This is the control reading.

7.4 Repeat 7.2 and 7.3 until at least 5 readings are recorded.

7.5 Repeat 7.2 - 7.4 using 5 chips exposed to 10 mR.

7.6 Repeat 7.2 - 7.4 using sets of 5 chips each, exposed to 15, 25, 60, 105, 300, 600, 1050, 3000 and 6000 mR.

7.7 Calculate the average reading for each dose, including the annealed control reading. Subtract the average control reading from each of the average dose readings. The results are the "net average dose" readings.

7.8 Calculate the correction factor for each dose by dividing the net average dose reading by the exposure.

7.9 Calculate the average correction factor from each of the individual correction factors for each exposure value.

7.10 Plot a curve of the net average dose readings (7.7) versus the exposure on 3 x 5 cycle log-log paper. This will become the primary calibration curve, and can be used to obtain the net exposure of a chip. The exposure may also be obtained by multiplying the average correction factor by the net nanocoulomb reading of an individual dosimeter.

7.11 To obtain the net exposure of a dosimeter, first subtract the control reading in nanocoulombs from the employee's reading in nanocoulombs. Then use this result to find the net exposure on the calibration curve.

8. <u>Routine Check Out Prior To Use</u>

8.1 If the system has been on overnight (preferable) proceed to Step 8.4, otherwise begin with Step 8.2.

8.2 Set up the system as in 7.1 with the exception that the meter switch is set to "zero". Do not turn on the nitrogen gas. Turn on the power switch and let the system warm up for at least 2 hours.

8.3 Check the zero setting by setting the toggle switch to "X.01", the needle should read on the zero set mark; if not, adjust as necessary.

8.4 Turn the meter switch to "current", turn on the nitrogen gas and set the regulator for 4 lpm. Let unit warm up for about 15 minutes at this setting.

8.5 Check the dark current, the needle should be reading between 1 to 2. If not, adjust the current suppression knob until it does.

8.6 Set the period to 10 seconds, open the drawer and depress the read button. The unit should read approximately 20 nanocoulombs after 10 seconds. If not, adjust the high voltage vernier until it does.

9. Strip Chart Recorder

9.1 Use the Varian Model G-1110 Strip Chart Recorder with a 100 millivolt span.

9.2 Connect the respective red and black recorder output leads (from the linear output socket) to the corresponding red and black input sockets on the recorder. Make sure the output switches on the backs of the Model 2000A and 2000B are set to 100 mv.

9.3 Set the speed ratio of the Varian at 1, the integrate switch to off and the chart speed switch at HI.

9.4 Turn on power to the recorder and check it for baseline zero. If the pen does not write along the baseline, remove the input signal leads and put a jumper wire across the input contacts. Using thumb adjustment knob on the rear of the recorder, adjust until the pen writes on the baseline. Remove the jumper and reconnect the signal leads.

9.5 Using the parameters in 7.1 with lithium fluoride chips, a correction factor of _____ is used to multiply the strip chart value of the _____°C peak to obtain an integrated nanocoulomb reading.

10. Evaluation of TLD Dosimeters

10.1 Set up the TLD system as in 7.1 and 9.3.

10.2 Using the vacuum handler, place an annealed chip in the depression of the heating pan, carefully close the drawer, allow the meter to stabilize between 1-2, then depress the read button.

10.3 The read light will remain on during the entire cycle. At the conclusion of the read cycle, record the reading in nanocoulombs on the worksheet and also on the strip chart.

10.4 Repeat Step 10.2 until a total of 5 annealed chips have been read. They should average within a range of .035-.050 nanocoulombs. If not, check the high voltage and current suppression settings.

10.5 These readings can be averaged and used as a control badge reading if a facility fails to return the control badge.

10.6 Before evaluating dosimeters from a new facility, record the date, evaluator's initials, facility and the operating parameters on the strip chart.

10.7 Place the control badge dosimeter of a facility in the planchet depression, carefully close the drawer, allow time for the dark current to stabilize and depress the read button.

10.8 Record the control reading at the conclusion of the read cycle on both the worksheet and on the right hand side of the strip chart opposite the peak.

10.9 Remove the dosimeter and place it in the "TO BE ANNEALED" container. Place an employee dosimeter in the planchet depression, making sure that the planchet temperature is below 100°C. Carefully close the drawer and depress the read button when the dark current has stabilized.

10.10 When the "Read" light goes out, record the dosimeter reading on both the worksheet and the strip chart. The worker's symbol and number is also to be recorded on the strip chart next to his reading.

10.11 Repeat Steps 10.9 and 10.10 for each dosimeter worn at the facility.

10.12 When all dosimeters from the first facility are read, follow steps 10.6 to 10.11 for all succeeding facilities.

10.13 Recheck the H.V. and current suppression periodically for drift. The 10 second open drawer H. V. test should read 20 nanocoulombs and the dark current should indicate 1-2.

10.14 At the conclusion of the day's activities, set the meter switch to off, leave the power supply on and turn off the nitrogen supply valve.

11. Report Generation

11.1 Add any new employees to the History Form.

11.2 Check the worksheet to make sure that all required entries are made.

11.3 Submit the History and Monthly Forms along with a completed keypunch request form to Keypunch Entry - A153, Martin Tower. Keypunch will submit all punched data directly to CDP. CDP will return all output to EQC.

11.4 Review the computer output for errors. If none, mail copies to the respective facilities as follows:

(a) All plants with Environmental Health Engineers: one copy of all reports for that plant to the Environmental Health Engineer. One copy to the respective facility.

(b) All facilities without Environmental Health Engineers: one copy to the Radiation Coordinator.

11.5 One copy each is to be retained by A. LaMastra and V. E. Kobrodo.

11.6 An annual report for each person badged can be requested after the December badge readings have been processed by CDP. This report is to be filed as the permanent record in each employee's folder.