ABSTRACT

STANLEY T. MAVROGIANIS. Establishment of a Quality Assurance Program for Burroughs Wellcome Co. Personnel Dosimetry Services. (Under the direction of Dr. James E. Watson.)

The Nuclear Regulatory Commission (NRC) is proposing amendments that would require its licensees to be accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) for Personnel Dosimetry Processors of the National Bureau of Standards (NBS). Burroughs Wellcome Co. feels it will have to adhere to this proposed requirement. A quality assurance program for the Burroughs Wellcome Co. personnel dosimetry services was established and is presented in this report. Technical areas of importance are documentation, personnel training, personnel competency, facilities and equipment, maintenance and calibration and record keeping. A calibration facility was setup and personnel were trained as to its proper operation. The Panasonic TLD Reader was calibrated and TLDs were submitted to a blind performance test.

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INTRODUCTION

Currently the Nuclear Regulatory Commission (NRC) is reviewing several studies that have been performed on proficiency testing of dosimetry processors. A significant percentage of the processors are not performing with a degree of accuracy acceptable to the NRC (Fe84). Because of the importance of personnel dosimetry measurements and the apparent poor performance of some processors, NRC considers that there is a need to evaluate the performance of personnel dosimetry processors periodically and to make a specific determination of competency. After reviewing various alternatives, the Commission is proposing amendments to the current 10CFR20 regulations requiring NRC licensees to utilize the services of personnel dosimetry processors accredited by the National Bureau of Standards (NBS) under the National Voluntary Lab Accreditation Program (NVLAP) (Fe84).

The laboratory accreditation program for personnel dosimetry processors was established by NBS in 1982 in response to a request from the Nuclear Regulatory Commission. The purpose of NVLAP is to (1) improve the accuracy of reported dose measurements made by personnel dosimetry processors and (2) to give recognition to competent processors. NVLAP criteria address the operation of the laboratory by focusing on the organizational structure, technical management, professional and ethical business practices, and the system for assuring the quality of test results. The criteria specify those fundamental elements necessary for the successful performance of routine services by applicants including staff competence and training, laboratory facilities and equipment, test plans, equipment calibration procedures, laboratory records, data handling procedures, and quality control checks and audits. Accreditation is a recognition of a processor's competence. In the context of the Dosimetry LAP this means that all of the necessary elements are present to conduct the processing functions for which accreditation is granted. Accreditation does not imply or warrant that a processor's reported doses are or always will be performed within the tolerance level specified in ANSI N13.11 to which compliance was demonstrated to gain accreditation. NBS does not monitor the daily operations of an accredited processor, and therefore is not responsible for either the quality of the work performed or the fees charged by the processor. Accreditation is not a guarantee of performance.

To become accredited, a processor must demonstrate the ability to meet the requirements of the NVLAP criteria. By establishing the proper quality assurance (QA) program the NVLAP requirements should be met consistently and with positive benefits to the processor involved. It is thought that the key to a properly functioning dosimetry program is to have and maintain an ongoing QA program. A QA program is defined as an organization's internal system of procedures and practices which assure the quality control of its services.

The purpose of this project was to review the dosimetry processing practices at Burroughs Wellcome Co. and to document these practices as well as suggest and document additional practices deemed necessary to meet NVLAP requirements. Instituting these new procedures has also required the recommendation and purchase of additional equipment to ensure the quality of dosimetry services at Burroughs Wellcome Co.

This work involved the preparation of a QA program and procedures (manual) suitable for daily use by the Burroughs Wellcome Co. The manual contains all the necessary QA aspects specified by NVLAP as well as items specifically applicable to the Burroughs Wellcome Co. The functional QA manual should be the guide for total operation of personnel dosimetry services.

In addition to the formulation of the manual, other work has involved the evaluation and positive recommendation as to the need for a calibration facility at Burroughs Wellcome Co. The design and implementation of the calibration facility are described in the discussion section of this report. The Panasonic system has a few unique features that should be discussed for a better understanding to be achieved by the reader. Therefore, included in the discussion section of this report are specific items of interest directly applicable to the operation of a Panasonic TLD reader. Also dosimeter test results for the Panasonic system, along with its quality assurance limits, are presented.

DISCUSSION

The Operation of a Panasonic TLD System

The Panasonic TLD System is a complex, sophisticated apparatus that allows dosimetry to be performed accurately and precisely when operated correctly. It is beyond the scope of this report to explain how the entire system works, but a few concepts and machine functions should be explained in order to give the reader a better comprehension of certain procedures. An explanation of the photon counter, frequency counter, crossover point between these two counters, and the use of the UD-815 TLD for automatic calibration purposes will be discussed (see Dosimetry Calibration and Processing Equipment Inventory section in Appendix for description of instruments used).

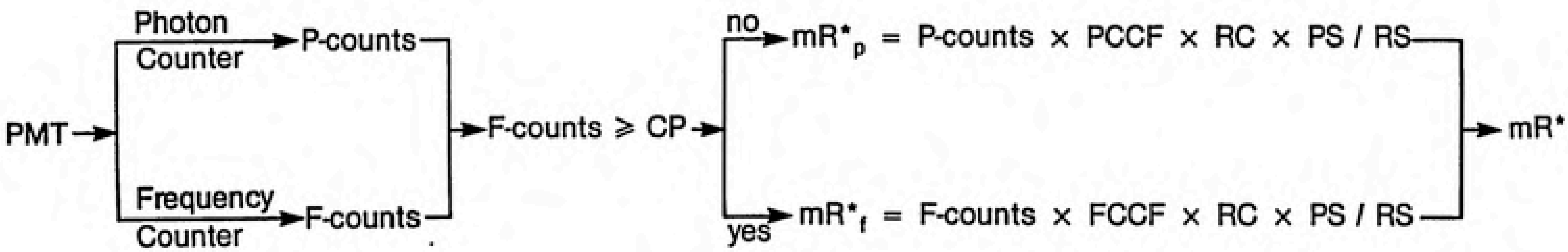
The use of the photon and frequency counter, as well as the functioning of a crossover point, will be explained first. When an element of a Panasonic dosimeter is heated by the heating lamp in the UD-710A Automatic TLD Reader, the light produced by the element is measured by a photomultiplier tube (PMT). The output from the PMT is quantified by a photon counter and by a frequency counter simultaneously. If the output from the PMT is small, the photon counter data are converted into a response for the element being read. If the output from the PMT is large, the data from the frequency counter are used. The crossover point is the output value from the PMT that determines whether the photon or frequency counter will be used to calculate the final response of an element. Below the crossover point (i.e., for small amounts of light from the PMT) the frequency counter is not linear with dose, and therefore the photon counter is used. Above the crossover point (i.e., for large amounts of light from the PMT) the frequency counter is used since the photon counter is not linear.

The output signals from the PMT are integrated digitally using a hybrid integrator. The integrator contains the photon counter and the frequency counter. The flow chart for the functions of this hybrid integrator is shown in Figure 1.

The photon counter counts pulses from the PMT until the crossover point is reached, at which point the frequency counter is used to integrate current. Each counter is linear for the range in which it is used to measure dose. The linearity of each counter within its intended range is shown in Figure 2, where the solid line shows the response (reading/exposure) as a function of exposure for the photon counter and the dashed line shows this response for the frequency counter. Figure 2 demonstrates the linearity of a TLD reader when properly calibrated using both counting systems.

Figure 1

Flow chart showing the sequence of operation of a Panasonic TLD reader.



PMT = photomultiplier tube
P-counts = counts measured by the photon counter
F-counts = counts measured by the frequency counter
CP = crossover point
PCCF = photon counter conversion factor
FCCF = frequency counter conversion factor
RC = rank correction factor
PS = phosphor sensitivity ratio
RS = reader sensitivity correction factor
mR_p^* = element response measured by the photon counter
mR_f^* = element response measured by the frequency counter
mR^* = element response displayed by the TLD reader

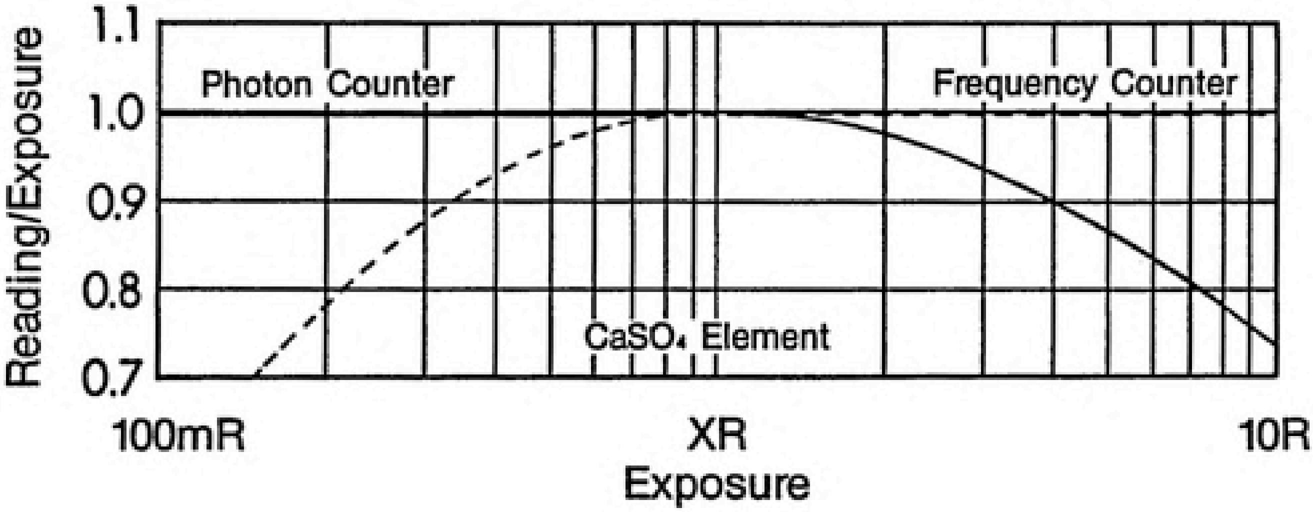


Figure 2

Typical shapes of the photon and frequency counter dose-response functions.

Both the photon counter and the frequency counter use a specific factor to convert counts to milliroentgens (mR). These factors are known as the photon counter conversion factor (PCCF) and the frequency counter conversion factor (FCCF). These conversion factors have units of mR/count. The PCCF and FCCF are established during calibration.

It is recommended that Burroughs Wellcome Co. only perform automatic calibrations of its TLD reader. It is the author's belief that manual calibration of the reader is too complex to be performed by Company personnel. Therefore, the quality assurance procedures written only incorporate automatic calibration of the TLD reader.

To do an automatic calibration it is mandatory to use the UD-815 dosimeter (see DSOP 7 in the Appendix). The UD-815 dosimeter contains no elements in positions 1 and 2 (usually used for $Li_2B_4O_7:C_u$), and it contains two replicate elements of $CaSO_4:T_m$ in positions 3 and 4. These elements are both encapsulated in 300 mg/cm^2 of plastic.

The use of UD-815 dosimeters is required to perform the automatic calibration of the UD-710 TLD reader. When the reader identifies a UD-815 dosimeter the central processing unit of the reader puts the reader in automatic calibration mode. By reading at least ten UD-815 dosimeters and following the procedures set forth in the Appendix a proper automatic calibration should be achieved. The two $CaSO_4$ elements in each and every UD-815 have a rank correction factor. The badges are selected to have a precision within three percent. Every Panasonic dosimeter is irradiated to a known dose from cesium-137 at the factory in Japan. The dosimeters are read in a Panasonic UD-710A Automatic TLD Reader 24 hours after irradiation to allow time for fading of lithium borate. The response of each element is compared to the response of a group of reference dosimeters, and an element correction factor (ECF) is calculated for each element. If an ECF is not within 0.70 to 1.40, the element is discarded. If an ECF is within this range, the closest of seven rank correction factors is assigned to the element and is encoded onto the dosimeter into which the element has been inserted.

A Panasonic TLD reader has the capability of reading and applying rank correction factors to dosimeters. The TLD reader may or may not apply these factors depending on how certain parameters are set.

Calibration Facility

In an effort to have the proper supporting equipment to operate a Panasonic Dosimetry System, it was deemed necessary to set up a facility capable of irradiating TLDs to verifiable doses. Burroughs Wellcome Co. chose to construct this facility with the purchase of two expensive and accurate pieces of equipment:

1) J. L. Shepherd Model 28-5D Calibrator

   It consists of a 120 mCi Cs-137 source and an attached calibration table for irradiating thermoluminescent dosimeters to precisely known and reproducible gamma dose levels.

2) Victoreen Model 570 Condenser R-Meter

It consists of an a.c. operated d.c. power supply, a complete dust-tight electrometer with its viewing microscope system, a lighting system for the microscope and the "ON-OFF" indicating light, and necessary operating controls. The Condenser R-Meter is used with interchangeable ionization chambers. This instrument has calibration directly traceable to the National Bureau of Standards (NBS).

With this equipment Burroughs Wellcome Co. has the capability of irradiating badges to known doses as well as accurately verifying that this dose is correct.

The exposure rate for the J. L. Shepherd Model 28-5D Calibrator has been measured twice, once by the manufacturer and once by the author, in order to verify the output. The manufacturer's calibration was done using a MDH Industries, Model 2025 X-ray Monitor, S.N. 2127, with 180 cc Probe, S.N. 6105 and 3 cc Probe, S.N. 4126. This meter was calibrated by MDH Industries, Inc. using a Model 10X5-6 modified 3-terminal Ion Chamber, S.N. X2, accuracy ± 5% (National Bureau of Standards Report #DG 7856/82). The author used a Victoreen, Model 570 Condenser R-Meter, S.N. 3856, with a Model 188 Chamber, S.N. 14098. Calibration is directly traceable to the NBS through periodic comparison of Victoreen's broad energy intercomparison standards (test report of energy intercomparison is not available). The author believes that correction for temperature and pressure was negligible, therefore, this correction was not performed.

The following table shows the response of both instruments at various distances.

Distance	Output Reported by Manufacturer	Output Measured by Author
20 cm	16.2 mR/min	16.8 mR/min
30 cm	7.06 mR/min	7.2 mR/min
40 cm	4.00 mR/min	4.0 mR/min
50 cm	2.59 mR/min	2.6 mR/min
60 cm	1.82 mR/min	1.8 mR/min

The output measured by the author shows the effect of the positioning of a large chamber volume in the radiation field. A graph of the output reported by the manufacturer versus distance is shown in Figure 3. Irradiations at the Burroughs Wellcome Co. will be done at distances of 40, 50, and 60 cm. Sixty centimeters is the preferred irradiation distance. At this distance, positioning of the dosimeter does not have to be as precise as with the closer distances. Positioning error has less effect on the dose rate at this distance.

Exposure was measured in mR/min due to the specific timer built into the calibrator. The Model X elapsed timer has a range of 9999.9 seconds with an accuracy of ± 0.1 second. This timer was verified by the author as working properly with a Fisher, Model Heuer Stopwatch, S.N. 758.301. The built-in timer corresponded precisely to the stopwatch for a 1 minute, 5 minute, 30 minute and 60 minute count. By knowing the timer is functioning precisely we have a degree of confidence when stating a unit of time.

The calibration table comes with a 4" high aluminum ring, for mounting dosimeters at the 60 cm source centerline to ring distance. Behind this ring a polyethylene tissue equivalent phantom was placed behind dosimeters to be irradiated to simulate a person. The use of a phantom assures that the dosimeter has the same probability of detecting backscattered radiation during calibration, as it does during normal use on the body. The dosimeters were not clipped directly to the phantom (there is a space of 1 to 3 cm) due to the arc in the calibration table and the clip associated with the badge hanger. The amount of variability due to the positioning of the badges relative to the calibration phantom is actually unknown, and should be explored further to assure the precision of calibration irradiations. Data were collected with and without the use of a phantom to show the effect, if any, of backscatter. Fifteen dosimeters were irradiated to 500 mR with and without the calibration phantom. The data in Table 1 and 2 show that the calibration phantom causes the UD-801 dosimeter, on the average, to respond 8% higher than without the phantom. This difference is not statistically significant, therefore, it is not conclusive that the calibration phantom caused a difference in response. Another test should be performed using a larger

Note: Element 2 is used as a good determination of dose since this element contains LiBO (thin and tissue equivalent) under 300 mg/cm^2 (sufficient to insure electronic equilibrium) of plastic (tissue equivalent).

number of badges and all the same type (UD-810 AQ) badges. This test design should help in showing whether there is a statistical difference with and without the use of a calibration phantom.

TABLE 1

TLD READINGS WITH THE USE OF A CALIBRATION PHANTOM

Dosimeter Number	E2 Delivered Dose (mR)	Reported Reading (mR)	E2 % Difference
1	500	644	28.8
2	500	565	13
3	500	577	15.4
4.	500	361	-27.8
5	500	634	26.8
6	500	548	9.6
7	500	583	16.6
8	500	475	-5.0
9	500	592	18.4
10	500	608	21.6
11	500	450	-10.0
12	500	422	-15.6
13	500	623	24.6
14	500	498	-0.4
15	500	521	4.2
		540	8.0%

$$E2\% \text{ Difference} = \frac{R - D}{D} \times 100$$

R = E2 Reported Reading

D = Delivered Dose

TABLE 2

TLD READINGS WITHOUT THE USE OF A CALIBRATION PHANTOM

Dosimeter Number	E2 Delivered Dose (mR)	Reported Reading (mR)	E2 % Difference
1	500	609	21.8
2	500	501	.2
3	500	469	-6.2
4	500	529	5.8
5	500	615	23
6	500	527	5.4
7	500	519	3.8
8	500	544	8.8
9	500	359	-28.2
10	500	557	11.4
11	500	433	-13.4
12	500	507	1.4
13	500	350	-30.0
14	500	473	-5.4
15	500	503	0.6
		499.6	≈0%

$$E2\% \text{ Difference} = \frac{R - D}{D} \times 100$$

R = E2 Reported Reading

D = Delivered Dose

Upon approval of establishing a calibration facility, the author began asking questions as to the correct handling of equipment and various so called "tricks of the trade" dealing with such a facility. In speaking with various health physic professionals it was brought to the author's attention that the J. L. Shepherd Calibrators had the reputation of emitting secondary electrons off the calibration table. To avoid this phenomenon the author elected to clip TLDs to the back of the holding tray. By allowing the aluminum tray to act as a shield, it can be shown that 98.4% of the gamma radiation penetrates through the aluminum and that the thickness of this aluminum is enough to totally eliminate the possible secondary electrons.

To prove that the gammas are making it through the aluminum, it must be shown that

$$e^{-\mu x} \cong 1,$$

where μ is the linear attenuation coefficient which is equal to the mass attenuation coefficient times the density of aluminum. The linear attenuation coefficient for Cs-137 is 0.202 cm^{-1}. The x term is the thickness of the aluminum tray on the calibrator which was 1/32" or 0.0792 cm.

Inserting the values into the exponential, the following result occurs.

$$e^{-(.202/cm)(.0792\ cm)} = 0.984 \cong 1$$

This means that 98.4% of the gammas make it through the aluminum with no scattering or no loss of energy. The other 1.6% of the gammas undergo some sort of scattering or energy change.

Assuming that the entire energy of a gamma (Cs-137, maximum gamma energy of .662 MeV) goes to the secondary electron, the maximum energy the particle may have would be .662 MeV. By finding the range of a .662 MeV beta particle in aluminum from the Radiological Health Handbook (p. 122, Penetration Ability of Beta Radiation), it is seen that the penetration range is 0.033 inches (BRH70). The aluminum tray is 0.0312 inches thick, therefore, leaving a difference of 0.0018.

0.033 - Beta Particle Range (inches)
-0.0312 - Aluminum Tray Thickness (inches)
0.0018

By stating a most conservative assumption (i.e., the secondary electron acquires the maximum gamma energy), the difference in the needed filtration is only 0.0018 inches. It is believed that with the added filtration of the badge hanger and the different filtrations over each element of the UD-801 that the remainder of the beta energy will be absorbed. Also of relevance would be the angle at which the beta particle hits the badge. With these variables in mind, it can be stated comfortably that a small fraction to none at all of the beta particle energy will be detected by a badge clipped to the back of the calibration tray.

RESULTS OF DOSIMETER TESTS

Throughout the procedures presented in the Appendix certain administrative limits were set in an effort to govern the quality of personnel dosimetry services at Burroughs Wellcome Co. These limits where established based on the experience of what is currently being done in the radiation protection industry. Results that lie within the boundaries of the limits are deemed a good indicator that dosimetry results have a high degree of confidence and results that exceed the limits are brought to the appropriate authorities attention. Dosimeter tests that are of greatest concern are the ± 15% value within which TLDs must respond to spot check calibration (see DSOP 3 and 7 in the Appendix), the ± 10% value within which TLDs must respond for validity verification of accuracy and precision for calibration purposes (see DSOP 7 in the Appendix), and the 4% residual dose limit of each TLD (see DSOP 3 in the Appendix). A group of twenty-five TLDs were exposed to 500 mR to test all the procedure limits. The data evaluated were taken directly from the reader without processing using the algorithm presented in the Appendix. Reader calibration is performed without use of the algorithm. All such results are presented in mR.

Another dosimeter test involved a mock NVLAP proficiency test with the University of Michigan (UM) (see DSOP 10, Appendix). University of Michigan staff allowed Burroughs Wellcome Co. to participate in a blind

Table 3

± 15% COMPARISON FOR ELEMENT 2

Dosimeter Number	Delivered Dose (mR)	E2 Reported Reading (mR)	E2% Difference	E3 Reported Reading (mR)	E3% Difference
1	500	487	-2.6	448	-10.4
2	500	516	3.2	574	14.8
3	500	464	-7.2	588	17.6
4	500	335	-33.0	500	0
5	500	486	-2.8	532	6.4
6	500	326	-34.8	588	17.6
7	500	498	-0.4	522	4.4
8	500	524	4.8	466	-6.8
9	500	406	18.8	602	20.4
10	500	566	13.2	543	8.6
11	500	458	-8.4	823	64.6
12	500	503	0.6	703	40.6
13	500	506	1.2	519	3.8
14	500	471	-5.8	510	2.0
15	500	426	-14.8	598	19.6
16	500	405	-19.0	501	.2
17	500	559	11.8	549	9.8
18	500	575	15.0	576	15.2
19	500	540	8.0	475	5
20	500	463	-7.4	540	8
21	500	515	3.0	545	9
22	500	458	-8.4	533	6.6
23	500	598	19.6	485	3.0
24	500	549	9.8	530	6.0
25	500	480	-4.0	633	26.6
Mean		484.6	-0.1	555.3	11.7
Standard Deviation		68.0	14.0	79.1	15.3

$$\% \text{ Difference} = \frac{R-D}{D} \times 100$$

R = Reported Reading

D = Delivered Dose

± 10% Limit

Another limit of importance is the ± 10% value within which TLDs must respond to check calibration. Prior to having to perform a calibration, a set of badges must be read and the average reading for each element must read within ± 10% and the percent standard deviation for each element must be ± 10% of the average reading or an automatic calibration must be performed. This limit is quite stringent, but it is believed that it has to be in order to use it as a method of checking calibration. The results of twenty-five readings, using Element 1, Element 2, and Element 3 are presented in Table 4. The data show that the only acceptable average element reading was Element 2. All of the percent standard deviations for each element exceeded ± 10% of the average reading. Does this mean that this test is unrealistic? It is the author's opinion that it is not. A calibration needs strict acceptance limits in order to assure that the machine is at the proper standards. The Panasonic TLD Reader at Burroughs Wellcome Co. did not respond with a desirable percentage of badges passing, but industry has shown that this limit is achievable. The author believes that Burroughs Wellcome Co. can realistically achieve this limit.

Table 4

± 10% COMPARISON FOR ALL ELEMENTS

Dosimeter Number	Delivered-Dose (mR)	E1 Reported Reading (mR)	% Diff.	E2 Reported Reading (mR)	% Diff.	E3 Reported Reading (mR)	% Diff.
1	500	699	39.8	487	-2.6	448	-10.4
2	500	666	33.2	516	3.2	574	14.8
3	500	445	-11	464	-7.2	588	17.6
4	500	466	-6.8	335	-33.0	500	0
5	500	529	5.8	486	-2.8	532	6.4
6	500	478	-4.4	326	-34.8	588	17.6
7	500	513	2.6	498	-0.4	522	4.4
8	500	665	33.0	524	4.8	466	-6.8
9	500	448	-10.4	406	18.8	602	20.4
10	500	612	22.4	566	13.2	543	8.6
11	500	518	3.6	458	-8.4	823	64.6
12	500	589	17.8	503	0.6	703	40.6
13	500	504	.8	506	1.2	519	3.8
14	500	550	100	471	-5.8	510	2.0
15	500	533	6.6	426	-14.8	598	19.6
16	500	616	23.2	405	19.0	501	0.2
17	500	522	4.4	559	11.8	549	9.8
18	500	660	32.0	575	15.0	576	15.2
19	500	625	25.0	540	8.0	475	5.0
20	500	543	8.6	463	-7.4	540	8.0
21	500	656	31.2	515	3.0	545	9.0
22	500	642	28.4	458	-8.4	533	6.6
23	500	710	42.0	598	19.6	485	3.0
24	500	704	40.8	549	9.8	530	6.0
25	500	401	-19.8	480	-4.0	633	26.6
Mean		571.8	14.4	484.6	-0.1	555.3	11.7
Standard Deviation		90.2	18.0	68.0	14.0	79.1	15.3

$$\% \text{ Difference} = \frac{R-D}{D} \times 100$$

R = Element Reported Reading

D = Delivered Dose

Table 5

ALL ELEMENT 4% RESIDUAL DOSE COMPARISON

Delivered Dose = 500 mR Residual Limit = 20 mR

Dosimeter Number	E1 Reported Reading (mR)	% Diff.	E2 Reported Reading (mR)	% Diff.	E3 Reported Reading (mR)	% Diff.	Exceeds Limit
1	18.3	3.7	17.2	3.4	19.5	3.9	
2	17.6	3.2	14.3	3.9	16.1	3.2	
3	15.0	3.0	15.5	3.1	15.9	3.2	
4	17.8	3.6	14.0	2.8	16.2	3.2	
5	14.9	3.0	15.3	3.1	17.0	3.4	
6	22.8	4.6	17.2	3.4	14.8	3.0	*
7	22.0	4.4	20.0	4.0	16.4	3.3	*
8	25.1	5.0	20.0	4	14.2	2.8	*
9	16.4	3.3	18.0	3.6	13.2	2.6	
10	20.0	4.0	22.8	4.6	14.8	3.0	*
11	20.0	4.0	15.7	3.1	15.7	3.1	
12	16.0	3.2	12.0	2.4	11.3	2.2	
13	26.5	5.3	23.5	4.7	13.5	2.7	*
14	16.1	3.2	22.4	4.5	16.1	3.2	*
15	17.5	3.5	21.9	4.4	11.0	2.2	*
16	18.9	3.8	14.9	3.0	18.4	3.7	
17	21.3	4.3	22.1	4.4	15.9	3.2	*
18	16.8	3.4	14.8	3.0	14.2	2.8	
19	14.4	2.9	16.3	3.3	10.7	2.1	
20	8.8	1.2	10.8	2.1	13.3	2.7	
21	12.8	2.6	11.4	2.3	15.9	3.2	
22	16.7	3.3	19.2	3.8	10.5	2.1	
23	10.6	2.1	18.0	3.6	17.7	2.9	
24	16.8	3.4	18.0	3.6	12.0	2.4	
25	9.5	1.9	7.0	1.4	10.1	2.0	

$$\% \text{ Difference} = \frac{R-D}{D} \times 100$$

R = Element Reported Reading

D = Delivered Dose

Table 6

University of Michigan Mock Proficiency Test

A test of the dosimeter reader was set up with the University of Michigan's (UM), School of Public Health, Radiological Health Program. This test required Burroughs Wellcome Co. to send 38 dosimeters (15 for beta particle exposure, 15 for high and low energy photon exposure, 4 controls, 4 spares) to UM for irradiation in Categories V (beta particles) and VI (photon mixtures) of the ANSI N13.11. These are the categories in which Burroughs Wellcome Co. feels it must become proficient in order to become accreditated by NVLAP. Burroughs Wellcome Co. currently uses two different dosimeters (see Performance of Old Versus New Design Dosimeter). Old design dosimeters were used for calibration of the TLD reader and new design dosimeters were sent to UM for the proficiency test. The new design dosimeters were read and submitted to the Burroughs Wellcome Co. algorithm. The algorithm results were then sent to UM.

A P value for each dosimeter was calculated using the following equation:

$$P = \frac{R - D}{D}$$

P = Performance Index

R = Reported Dose

D = Delivered Dose

The average of the P values for each category, $\bar{P}$, and its standard deviation, S, are computed for each category. The value of $\bar{P}$ indicates any bias in the dosimetry system, with $\bar{P} = 0$ being perfect. The value of S is an indication of the precision of the dosimetry system, with S = 0 being perfect. For a passing mark in these categories $|\bar{P}|$ plus S must be less than or equal to 0.5.

The results indicate that Category V was failed with $|\bar{P}|$ plus S = 1.43, and both shallow dose and deep dose tests of Category VI were passed. Category V has a high bias of 0.61 and a high precision term of 0.82. For Category VI there is a negative 0.14 bias at the shallow depth and a negative 0.01 bias at the deep depth, both of which are acceptable. The precision values are .14 at the shallow depth and .20 at the deep depth, both of which are again acceptable. Data can be seen in Tables 6, 7, 8, and 9.

The results in the Category VI are deceiving. The new dosimeters used during this test underrespond compared to the old dosimeters used during calibration. However, this effect is counterbalanced since the algorithm used at Burroughs Wellcome Co. overstates the known dose by approximately the same amount that the new dosimeter underresponds to the known dose. The end result was an acceptable performance on the proficiency test (see Performance of Old Versus New Design Dosimeter for details about the response of each dosimeter).

Table 6

CATEGORY VI: HIGH -ENERGY COMPONENT
OF PHOTON MIXTURES
RADIATION SOURCE: CESIUM-137
IRRADIATION DISTANCE: 100 CM TO FRONT FACE OF PHANTOM

PROCESSOR NAME: BURROUGHS WELLCOME CO.
TYPE OF DOSIMETER: PANASONIC UD-801 TLD

		IRRADIATION INFORMATION			DELIVERED DOSE EQUIVALENT	
Dosimeter Number	Date Irradiated	Rate (mR/Min)	Time (Min)	Total (mR)	Shallow Cx = 1.03 (mrem)	Deep Cx = 1.03 (mrem)
1	84-12-12	83.22	2.94	244.7	252.0	252.0
2	84-12-12	83.22	2.67	222.2	228.9	228.9
3	84-12-12	83.22	0.45	37.4	38.6	38.6
4	84-12-12	83.22	1.29	107.4	110.6	110.6
5	84-12-12	83.22	20.10	1672.7	1722.9	1722.9
6	84-12-12	83.22	0.63	52.4	54.0	54.0
7	84-12-12	83.22	1.11	92.4	95.1	95.1
8	84-12-12	83.22	16.92	1408.1	1450.3	1450.3
9	84-12-12	83.22	1.40	116.5	120.0	120.0
10	84-12-12	83.22	12.60	1048.6	1080.0	1080.0
11	84-12-12	83.22	13.83	1150.9	1185.5	1185.5
12	84-12-12	83.22	0.94	78.2	80.6	80.6
13	84-12-12	83.22	0.82	68.2	70.3	70.3
14	84-12-12	83.22	1.15	95.7	98.6	98.6
15	84-12-12	83.22	5.96	496.0	510.9	510.9

Table 7

CATEGORY VI: LOW -ENERGY COMPONENT
OF PHOTON MIXTURES
RADIATION SOURCE: X-RAY TECHNIQUE LK
IRRADIATION DISTANCE: 100 CM TO FRONT FACE OF PHANTOM

PROCESSOR NAME: BURROUGHS WELLCOME CO.
TYPE OF DOSIMETER: PANASONIC UD-801 TLD

		IRRADIATION INFORMATION			DELIVERED DOSE EQUIVALENT	
Dosimeter Number	Date Irradiated	Rate (mR/Min)	Time (Min)	Total (mR)	Shallow Cx = 1.14 (mrem)	Deep Cx = 0.95 (mrem)
1	84-11-29	412.90	0.30	123.9	141.2	117.7
2	84-11-29	412.90	0.75	309.7	353.0	294.2
3	84-11-29	412.90	0.25	103.2	117.7	98.1
4	84-11-29	412.90	0.11	45.4	51.8	43.1
5	84-11-29	412.90	2.33	962.1	1096.7	914.0
6	84-11-29	412.90	0.16	66.1	75.3	62.8
7	84-11-29	412.90	0.14	57.8	65.9	54.9
8	84-11-29	412.90	4.75	1961.3	2235.9	1863.2
9	84-11-29	412.90	0.11	45.4	51.8	43.1
10	84-11-29	412.90	1.33	549.2	626.0	521.7
11	84-11-29	412.90	2.13	879.5	1002.6	835.5
12	84-11-29	412.90	0.44	181.7	207.1	172.6
13	84-11-29	412.90	0.09	37.2	42.4	35.3
14	84-11-29	412.90	0.14	57.8	65.9	54.9
15	84-11-29	412.90	0.51	210.6	240.1	200.0

Table 8

CATEGORY VI: SUMMARY OF PHOTON MIXTURES

PROCESSOR NAME: BURROUGHS WELLCOME CO.
TYPE OF DOSIMETER: PANASONIC UD-801 TLD

	TOTAL SHALLOW DOSE EQUIVALENT			TOTAL DEEP DOSE EQUIVALENT		
Dosimeter Number	Delivered (mrem)	Reported (mrem)	P	Delivered (mrem)	Reported (mrem)	P
1	393.2	430.1	0.0938	369.7	369.1	-0.0016
2	581.9	517.5	-0.1107	523.1	554.3	0.0597
3	156.2	138.0	-0.1168	136.6	165.0	0.2076
4	162.4	177.1	0.0908	153.7	171.8	0.1176
5	2819.6	2288.5	-0.1884	2636.9	2602.7	-0.0130
6	129.3	110.7	-0.1439	116.8	132.3	0.1331
7	161.0	99.0	-0.3853	150.1	88.0	-0.4136
8	3686.2	2978.5	-01920	3313.5	2916.9	-0.1197
9	171.8	134.5	-0.2170	163.2	185.8	0.1388
10	1706.1	1440.0	-0.1560	1601.7	1139.9	-0.2883
11	2188.1	1736.5	-0.2064	2021.0	2242.6	0.1097
12	287.7	185.4	-0.3555	253.2	158.2	-0.3751
13	112.7	109.6	-0.0271	105.6	113.0	0.0702
14	164.5	173.6	0.0555	153.5	181.4	0.1818
15	750.9	595.7	-0.2067	710.9	786.0	0.1056

$\bar{P}$ =	-0.14		$\bar{P}$ =	-0.01
S =	0.14		S =	0.20
$\lvert\bar{P}\rvert$ + S =	0.28		$\lvert\bar{P}\rvert$ + S =	0.21
L =	0.50		L =	0.50
Pass			Pass	

Table 9

CATEGORY V: BETA PARTICLES
RADIATION SOURCE: STRONTIUM/YTTRIUM-90
IRRADIATION DISTANCE: 35 CM CORRECTED TO 34.6 CM

PROCESSOR NAME: BURROUGHS WELLCOME CO.
TYPE OF DOSIMETER: PANASONIC UD-801 TLD

		IRRADIATION INFORMATION			SHALLOW DOSE EQUIVALENT		
Dosimeter Number	Date Irradiated	Rate (mrad/Min)	Time (Min)	Total (mrad)	Delivered (mrem)	Reported (mrem)	P
16	84-12-5	154.51	3.92	605.7	605.7	1545.8	1.5522
21	84-12-5	154.51	1.29	199.3	199.3	516.8	1.5928
19	84-12-5	154.51	5.60	865.3	865.3	674.0	-0.2210
22	84-12-5	154.51	2.61	403.3	403.3	814.2	1.0190
17	84-12-5	154.51	45.57	7041.1	7041.1	5686.5	-0.1924
28	84-12-5	154.51	1.36	210.1	210.1	398.8	0.8978
20	84-12-5	154.51	27.08	4184.2	4184.2	2762.5	-0.3398
24	84-12-5	154.51	1.69	261.1	261.1	717.4	1.7474
27	84-12-5	154.51	5.48	846.7	846.7	621.3	-0.2662
29	84-12-5	154.51	7.63	1178.9	1178.9	673.2	-0.4290
23	84-12-5	154.51	1.44	222.5	222.5	361.1	0.6229
25	84-12-5	154.51	3.34	516.1	516.1	1187.1	1.3003
26	84-12-5	154.51	4.51	696.8	696.8	1470.3	1.1099
30	84-12-5	154.51	20.10	3105.7	3105.7	2048.5	-0.3404
18	84-12-5	154.51	12.37	1911.3	1911.3	3988.4	1.0867

$\bar{P} = 0.61$
$S = 0.82$

$|\bar{P}| + S = 1.43$
$L = 0.50$
Fail

Performance of Old Versus New Design Dosimeter

Burroughs Wellcome Co. is currently using two different design types of the Panasonic UD-801 TLD. The difference in the two designs is the phosphor backing of each element in the dosimeter. The new design dosimeter contains a phosphor backing that supposedly makes the dosimeter less susceptible to moisture. Tests were performed to determine whether this new design dosimeter responds differently than the old design dosimeter when all other variables are held constant.

Thirty old and new badges were irradiated to 500 mR to see how each design responded. From Tables 10, 11, and 12 it can be seen that the difference in response from the known irradiated value for Element 2 is -3.2% for the old design compared to -30.2% for the new design. The deep doses determined using the algorithm show a difference in response from the known dose equivalent of 15.7% for the old design compared to -7.2% for the new design. The old design dosimeter was used during calibration.

The old design dosimeter Element 2 responded closely to the known irradiated value, yet the reported deep dose is off by 15.7%. Element 2 of the new design dosimeter responds 30.2% below the known dose, yet the reported deep dose determined by the algorithm is only 7.2% below the actual delivered dose. Thus the algorithm that the reported element readings are submitted to produces a deep dose greater than the Element 2 readings. The dosimeters were irradiated with Cs-137 source, therefore the high-energy photon component of the algorithm is responsible for determining dose. This component of the algorithm looks at the ratio B:

$$B = \frac{\text{Element 1 Reading}}{\text{Element 3 Reading}}$$

If $B \leq 2$, then a deep dose for higher energy photons is calculated by using

$$Hd = (1.85 - 0.55\ B)E_2.$$

This dose equivalent calculation encompasses an energy range of 29 KeV x-ray to Co-60 (1.173 MeV gamma, 1.332 MeV gamma). The report that the algorithm was taken from states that "$(1.85 - 0.55\ B)E_2$, is a compromise to satisfy several types of mixtures of radiation. As with any compromise, the method is just barely satisfactory at the extremes." (P179) The report goes on to state that values of B for this energy range lie between 0.7 and 1.5. At these values the dose reported will be 46.5% to 2.5% greater than the Element 2 reading. On the average Element 2 of the old design dosimeter is multiplied by 1.29, and Element 2 of the new design dosimeter multiplied by 1.40. The old design dosimeter had a favorably average reading for Element 2 yet when submitted to the algorithm (i.e., multiply Element 2 by 1.29) the reported deep dose is overstated by 15.7%. Also, the new design dosimeter understates Element 2, yet when submitted to the algorithm (i.e., multiply Element 2 by 1.40) the reported deep dose is almost correct.

By looking at the response of Element 2 for the old and new design dosimeters, it can be seen that the response of the two design types is different.

Table 10

RESPONSE OF OLD DESIGN DOSIMETER

Dosimeter Number	Delivered Dose (mR)	E2 Reported Reading (mR)	Delivered Dose (mrem = 1.03 mR)	Reported Deep Dose (mrem)
1	500	593	515	778.1
2	500	598	515	675.3
3	500	583	515	730.5
4	500	418	515	609.9
5	500	320	515	353.4
6	500	509	515	732.0
7	500	351	515	381.0
8	500	542	515	591.9
9	500	510	515	652.4
10	500	476	515	745.5
11	500	501	515	638.7
12	500	443	515	596.9
13	500	324	515	341.5
14	500	530	515	661.2
15	500	447	515	403.6
16	500	487	515	576.0
17	500	500	515	696.1
18	500	395	515	581.8
19	500	532	515	684.7
20	500	401	515	548.3
21	500	519	515	645.4
22	500	602	515	592.0
23	500	429	515	622.6
24	500	559	515	700.5
25	500	561	515	684.8
26	500	489	515	543.3
27	500	537	515	743.1
28	500	474	515	469.9
29	500	464	515	473.1
30	500	424	515	441.5
Mean		484		597
Standard Deviation		77		123

Table 11

RESPONSE OF NEW DESIGN DOSIMETER

Dosimeter Number	Delivered Dose (mR)	E2 Reported Reading (mR)	Delivered Dose (mrem = 1.03 mR)	Reported Deep Dose (mrem)
1	500	415	515	590.6
2	500	329	515	432.9
3	500	367	515	501.8
4	500	304	515	435.9
5	500	369	515	499.9
6	500	295	515	424.4
7	500	351	515	504.2
8	500	324	515	479.3
9	500	343	515	356.4
10	500	359	515	505.5
11	500	336	515	478.2
12	500	296	515	435.7
13	500	325	515	343.2
14	500	430	515	592.6
15	500	288	515	411.4
16	500	350	515	489.7
17	500	313	515	438.0
18	500	336	515	467.9
19	500	407	515	532.7
20	500	293	515	413.2
21	500	398	515	538.3
22	500	320	515	469.7
23	500	377	515	531.0
24	500	377	515	543.3
25	500	326	515	473.5
26	500	374	515	552.6
27	500	371	515	490.5
28	500	419	515	541.8
29	500	329	515	349.9
30	500	343	515	518.2
Mean		349		478
Standard Deviation		39		65

CONCLUSIONS AND RECOMMENDATIONS

It is the author's belief that this project has laid a solid foundation for a dosimetry program at Burroughs Wellcome Co. The work accomplished has included documentation of dosimetry procedures, establishment of an irradiation facility, calibration of the Panasonic UD-710A Automatic TLD Reader, and a mock proficiency test with the University of Michigan. This work gives Burroughs Wellcome Co. an indicator as to how its dosimetry services are currently functioning. Presented below are conclusions and recommendations that should help Burroughs Wellcome Co. in obtaining NVLAP accreditation.

The author evaluated current Burroughs Wellcome Co. dosimetry practices and documented these practices into what is thought to be a realistic, functional program for such a facility. This program is important in that it gives Burroughs Wellcome Co. procedures to use for routine dosimetry activities, as well as provide detailed documentation of the dosimetry practices as required by NVLAP accreditation criteria.

It was deemed necessary to establish a facility capable of irradiating TLDs to known doses. This was accomplished by the acquisition of a J.L. Shepherd Model 28-5D Irradiator and a Victoreen Model 570 Condenser R-meter. The first piece of equipment allows the Company to irradiate TLDs and the latter verifies the correct exposure. With this equipment, the Company has the capability of doing automatic calibrations, calibration checks of the TLD reader, and quality control testing of all dosimeters. These are all necessary functions of the dosimetry program established (i.e., Appendix).

During this project it became evident that the Panasonic UD-710A Automatic TLD Reader needed calibrating (see DOSP-7, Appendix). The data below show that both conversion coefficients more than doubled as a result of the calibration.

PANASONIC UD-710A AUTOMATIC TLD READER
CONVERSION COEFFICIENTS FOR OLD DESIGN DOSIMETER

	Previous Reader Con. Coeffic.	Calibrated Reader Con. Coeffic.
Photon Counter	298 E-5 mR/cts	689 E-5 mR/ct
Frequency Counter	1172 E-3 mR/cts	2803 E-3 mR/ct

Burroughs Wellcome Co. contracted the services of the University of Michigan to irradiate TLDs in Categories V ad VI of the ANSI 13.11-1983 standard. The test is an excellent indicator as to how the Company will do with the proficiency testing of NVLAP and it also reveals the current accuracy or deficiency in reporting doses at Burroughs Wellcome Co. Category VI, photon mixtures passed the 0.5 tolerance limit with values of 0.28 shallow dose and 0.21 deep dose. The results showed that Category V, beta particles, failed the tolerance limit of 0.5 by a |P| + S value of 1.43.

In the opinion of the author, these results indicate the Company needs to reevaluate its procedures for beta measurement. It is beyond the scope of this project to rectify this problem, but a possible area of concern could be the algorithm that the badge readings are processed through. The author recommends that further research should be done to rectify the beta dose measurement problem at Burroughs Wellcome Co. before applying to NVLAP. Category VI, photon mixtures (|P| + S value of 0.28 shallow, 0.21 deep) passed the proficiency test, but further evaluation is still needed due to the high standard deviations in the badge readings, the old versus new design dosimeter used during the test, and possible inadequacies with the dose algorithm used.

The purpose of this project is to give Burroughs Wellcome Co. the necessary procedures and documentation to gain accreditation by NVLAP. However, it is the author's opinion that accreditation would not be granted at the present time. The author feels that now the Company has a foundation for a dosimetry program, but not the overall dedication to dosimetry necessary to meet accreditation. It is the author's belief that the Company must decide whether to follow through with a dosimetry program or pursue some other alternative. Presented below are recommendations that the Company is suggested to follow-up on if a dosimetry program is to be properly established.

Dosimetry records are of utmost importance and provide documented proof that dosimetry practices are being carried out. The author believes that more attention to documentation is needed. Currently, personnel dose reports are being generated and documented, but there are other dosimetry records that need to be generated and filed. Examples of additional documentation such as DSOP Forms and printouts are described throughout the Appendix. All the forms, parameter dumps, and hard copy dose data need to be retained for the specified period. NVLAP will review all of these records as part of their evaluation.

To meet NVLAP requirements it is necessary to properly train and to periodically retrain personnel carrying out dosimetry services. Currently, dosimetry personnel have taken an introductory course on using the Panasonic system as part of their initial training, but there has been no further training or assessment of performance since that time. It is the author's opinion that the Company must form a better training-retraining apparatus for dosimetry personnel. Dosimetry Qualification Records (see Appendix, DSOP 11) have been developed with suggestions as to the correct training for each procedure.

Presently, the dosimetry program at Burroughs Wellcome Co. has only the Staff Specialist performing dosimetry related duties. The Corporate Radiation Safety Officer (CRSO) serves as the backup to the Staff Specialist. If the Staff Specialist becomes ill, the CRSO should not be burdened with the added responsibility of performing dosimetry duties. Therefore, the author suggests that an additional Burroughs Wellcome Co. employee be trained to operate the Panasonic TLD system. This newly trained individual should assure that dosimetry services are performed without interruption in the case of employee illness, termination, or death.

Another important quality assurance consideration is the upkeep of dosimetry equipment. Proper maintenance and calibration of equipment are cornerstones of any successful quality assurance program. The author has observed various shortcomings in equipment maintenance (laboratory cleanliness, equipment quality control checked) and calibration, brought them to the responsible authorities attention, and the problems were normally rectified. It is not intended or inferred that Burroughs Wellcome Co. is not maintaining their equipment in a desired manner, but it is the author's intention to instill an "awareness" of the importance of maintenance and calibration.

The author suggests that Burroughs Wellcome Co. contact the Panasonic Company and exchange all the old design dosimeters for new design dosimeters. An additional dosimeter related recommendation is the need to evaluate the variation in response between different elements in the same TLD as well as variations between different TLDs. The difference in response in the elements ($\pm$ 10% Comparison for all Elements) and the large standard deviations associated with various TLD readings (Old versus New Design Dosimeter) indicates that further investigation is needed.

As previously stated, the algorithm that the element readings are submitted to needs reevaluation. The current algorithm was formulated in 1979. Since that time there is more knowledge about the Panasonic TLD System. With this additional information, Burroughs Wellcome Co. should formulate an algorithm suitable to the isotopes that are being monitored for.

Burroughs Wellcome Co. must now decide whether to pursue NVLAP accreditation further. With the foundation that this project has laid and addressing the recommendations previously presented, NVLAP accreditation is thought to be obtainable.

REFERENCES

Fe84 Federal Register, "Improved Personnel Dosimetry Processing," Vol. 49, No. 6, January 1984, 1205-1211.

P179 Plato Phillip, Hudson Glenn, "Calibration of Panasonic Model UD-710A Automatic TLD Reader and UD-801A Personnel Dosimeters," University of Michigan, December 1979.

BRH70 Radiological Health Handbook, U.S. Department of Health, Education, and Welfare Public Health Service, January 1970.

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

APPENDIX

Quality Assurance Program for Burroughs Wellcome Co. Personnel Dosimetry Services

Presented by

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April 18, 1985

TAM2-269/i/ja

WELCOME TO BURROUGHS WELLCOME CO.

Burroughs Wellcome Co. has been an integral part of the health care system of the United States since the early years of the century. During that time, the Company's discoveries have provided support to the medical profession by contributing to the alleviation of a wide range of disease conditions. Quality pharmaceutical products are manufactured and marketed to treat a variety of ailments (Bu82).

With a diverse research community, Burroughs Wellcome Co. frequently finds it necessary to employ the use of various radionuclides. In using radionuclides Burroughs Wellcome Co. must adhere to all North Carolina State Regulations administered by the Radiation Protection Section of the Department of Human Resources in order to maintain its Radioactive Materials Specific License of Broad Scope. One of these regulations requires the monitoring of radiation exposure of personnel and keeping records of this exposure.

The purpose of this manual is to provide the proper procedures and documentation necessary to meet the requirements set forth by the National Bureau of Standards National Voluntary Laboratory Accreditation Program (NVLAP) for dosimetry processors. Through the joint efforts of the Radiation Protection Department at Burroughs Wellcome Co. and the Radiological Hygiene Program at the University of North Carolina at

Chapel Hill, this quality assurance manual was produced for use as the guideline for dosimetry services at Burroughs Wellcome Co. This manual provides the plan of action necessary for accurate measurement of radiation exposure.

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are P-32 and I-125. With the proper equipment and an understanding of the isotopes involved, personnel monitoring can be performed correctly.

Burroughs Wellcome Co. requires all personnel who have the slightest chance of radiation exposure to wear a TLD. These badges are exchanged monthly and processed to determine dose to each worker (dose meaning dose equivalent). Workers with doses in excess of expected values are warned and educated as to techniques for lowering their exposure. All workers' doses are documented and the records are stored for at least a thirty year period. Every effort is made by the Radiation Protection Department to keep exposure as low as reasonably achievable (ALARA).

The North Carolina State Radiation Protection Section of the Department of Human Resources has reviewed American National Standard N13.11-1983 and nuclide inventories at Burroughs Wellcome Co. facilities to choose the proper categories for accreditation in the National Voluntary Laboratory Accreditation Program (NVLAP) for dosimetry processors. The categories of greatest relevance are beta particles (Category V, Am83) and photon mixtures (high and low energy photons, Category VI, Am83). With accreditation by NVLAP in these categories and adherence to the procedures set forth, personnel dosimetry services at Burroughs Wellcome Co. should operate with a high degree of confidence.

BURROUGHS WELLCOME CO. ORGANIZATIONAL STRUCTURE

Burroughs Wellcome Co. is a wholly-owned subsidiary of the Wellcome Foundation, Ltd., headquartered in London, England. The Company was founded by two young American pharmacists, Silas M. Burroughs of New York and Henry S. Wellcome of Wisconsin. Burroughs and Wellcome were initially involved in the distribution of drugs from England to America and markets in other parts of the world. In 1906, a company with administrative and manufacturing facilities was started in New York (Bu82).

Since that time, Burroughs Wellcome Co. has moved its corporate headquarters to the Research Triangle Park in North Carolina. Under the direction of President William M. Sullivan, the Company has made progress in the medical pharmaceutical industry. Mr. Sullivan reports to and is on the Corporate Board of Directors in England. He heads the entire operating organization in the United States. Under his direction are many vice presidents and major functional heads (Figure 1).

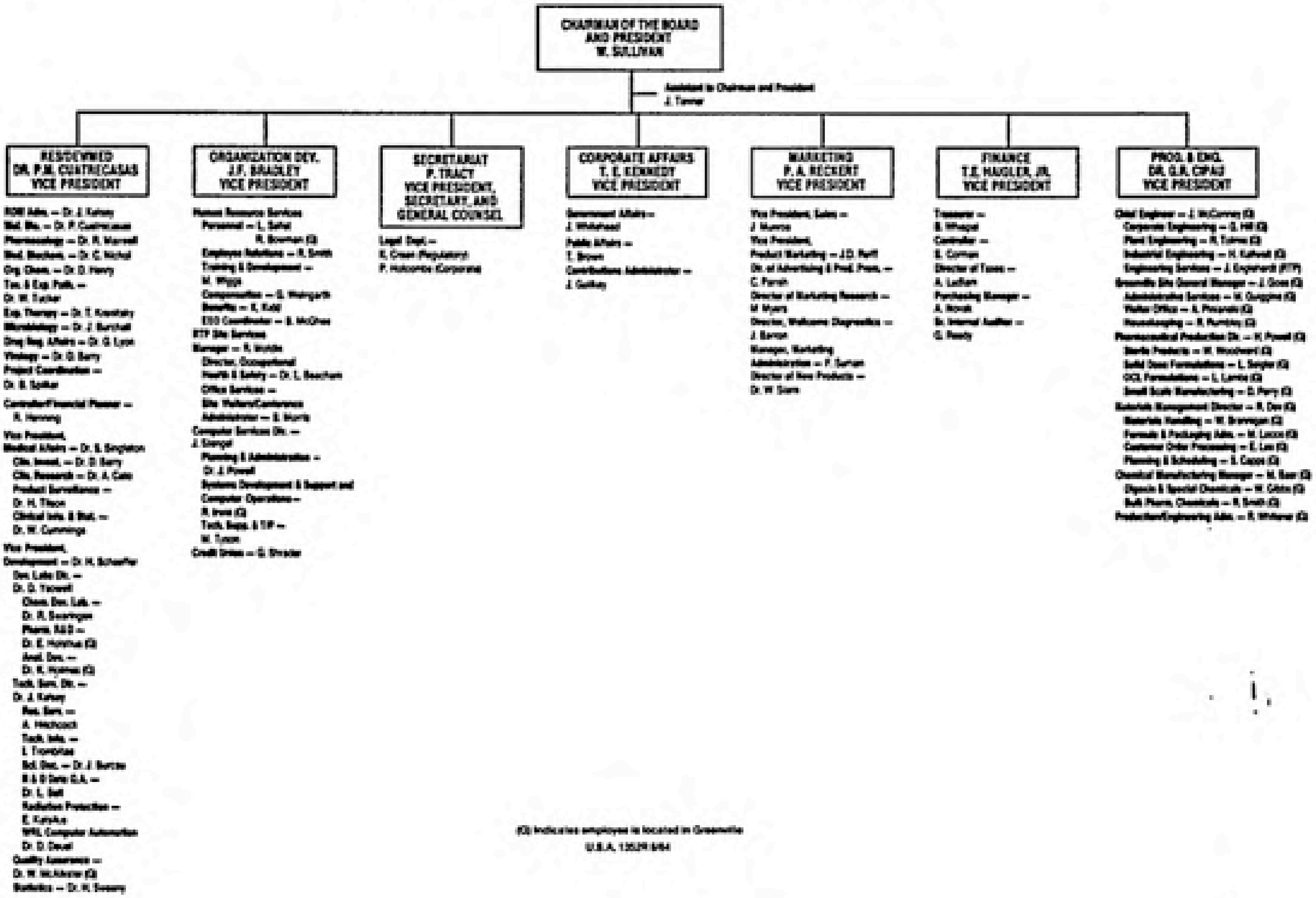
The Research, Development, and Medical Sections, under the direction of Dr. Pedro M. Cuatrecasas contains the Radiation Protection Department (Figure 2). The Radiation Protection Department is responsible for administering all health physics practices as well as adhering to all North Carolina State Radiation Protection Regulations.

Positions in the Radiation Protection Department have the following job descriptions. Organizational structure is also provided with specific emphasis on the Radiation Protection Department (Figure 2).

FIGURE 1

B.W. CO® ORGANIZATION CHART

UNIT MANAGERS & MAJOR FUNCTIONAL HEADS



(G) Indicates employee is located in Greenville

A) Corporate Radiation Safety Officer (CRSO)

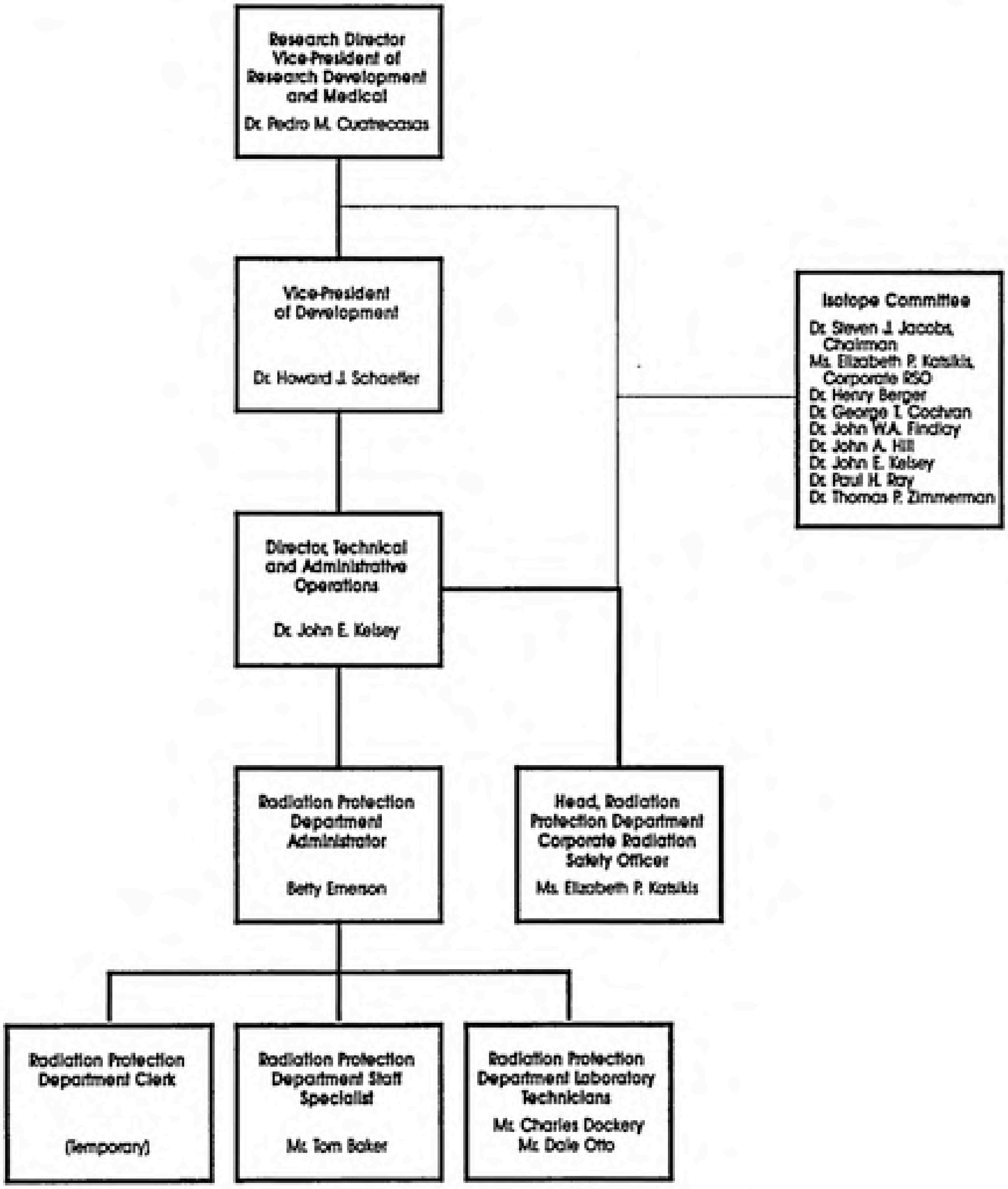
The CRSO has direct responsibility of the technical overview of the entire Radiation Protection Department. He or she must also act in a liaison capacity between Burroughs Wellcome Co. and the North Carolina State Radiation Protection Section of the Department of Human Resources and between the Isotope Committee and the individual senior research staff member using radioactive materials and/or supervising the use of radioactive materials. The CRSO must ensure adherence to all safety guidelines established by the North Carolina State Radiation Protection Section and the Isotope Committee. (Company regulations and limits are normally more stringent than those administered by the State.)

B) Administrator, Radiation Protection Department

He or she is responsible for developing and supervising implementation of all administrative duties, such as reports, computer programs and mandatory files to assure all state and federal regulations are adhered to protecting the integrity of Burroughs Wellcome Co.'s broad license, manufacturing license, and air permit. The Administrator must secure the radionuclides requested by the research staff in an expeditious manner. Also, he or she must arrange the shipping of radioactive materials from Burroughs Wellcome Co., implementing Company and government requirements, as well as supervise all Radiation Protection Department staff.

answering the telephone, arranging meetings, making travel arrangements, and assisting departmental members with various clerical duties as requested.

Figure 2
BURROUGHS WELLCOME CO.
Radiation Protection Program
Organizational Structure



BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY CALIBRATION AND PROCESSING FACILITIES

The Radiation Protection Department is located on the first floor on the Toxicology Building (B-25). The TLD Processing Facility is in the laboratory room adjacent to the main departmental office (B-26, Figure 3). The Calibration Facility is located in the South Building (0144, Figure 4). Specific features of the facilities are:

A) Ample Space to Perform Calibration and Processing of TLDs (Figure 3 and 4)

The laboratory and calibration facilities allow technicians to move around without hindrance. There are many lab tables providing an abundance of storage space in the processing areas.

B) Modern Processing Equipment

The laboratory contains the Panasonic UD-710A Automatic TLD Reader and all the extra Panasonic TLDs. There are approximately 850 TLDs available. The Calibration Facility located in the South Building, contains the J. L. Shepherd Model 28-5D Calibrator.

Figure 3
BURROUGHS WELLCOME CO.
Radiation Protection Department
Office and Laboratory Facility

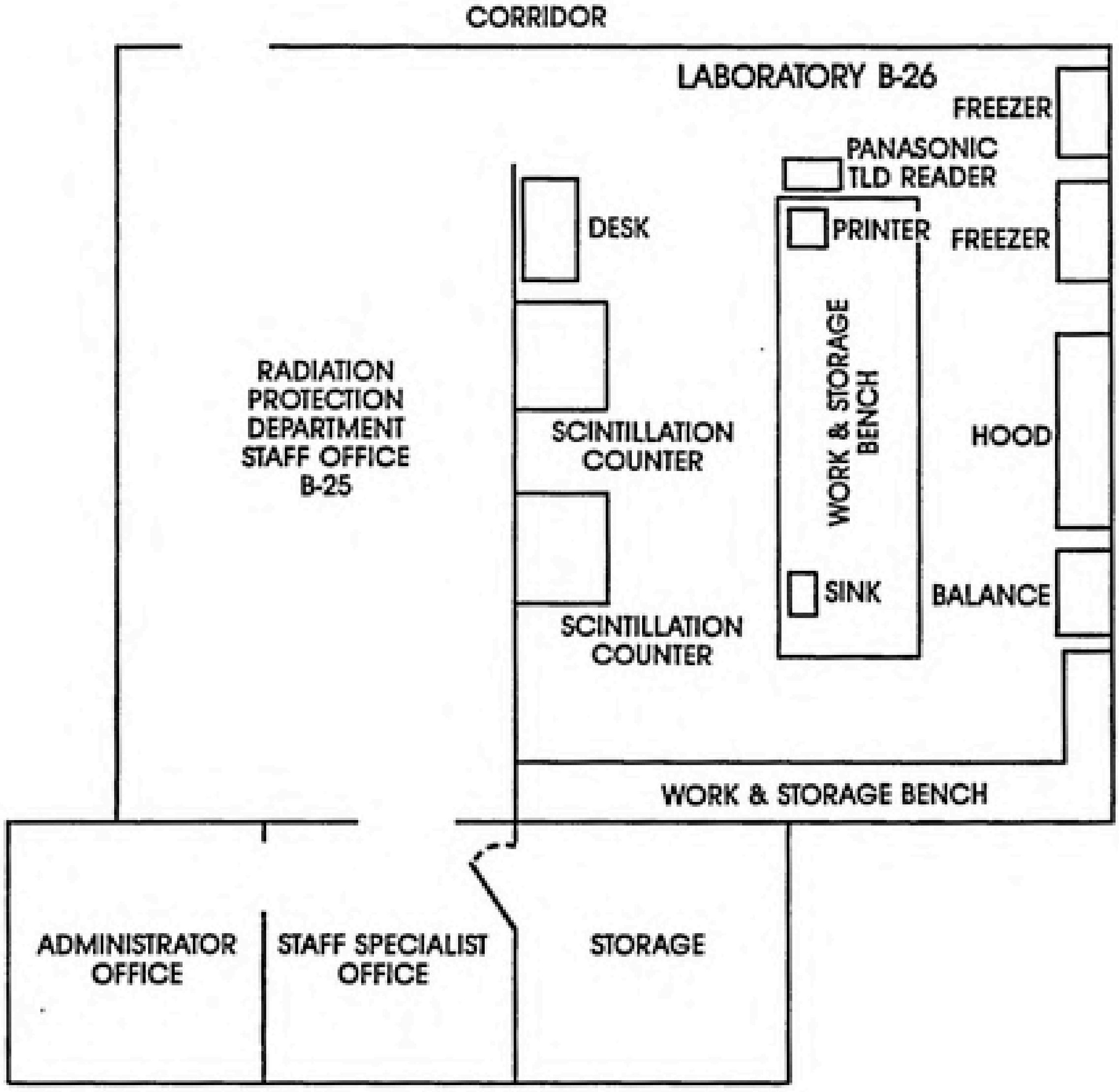
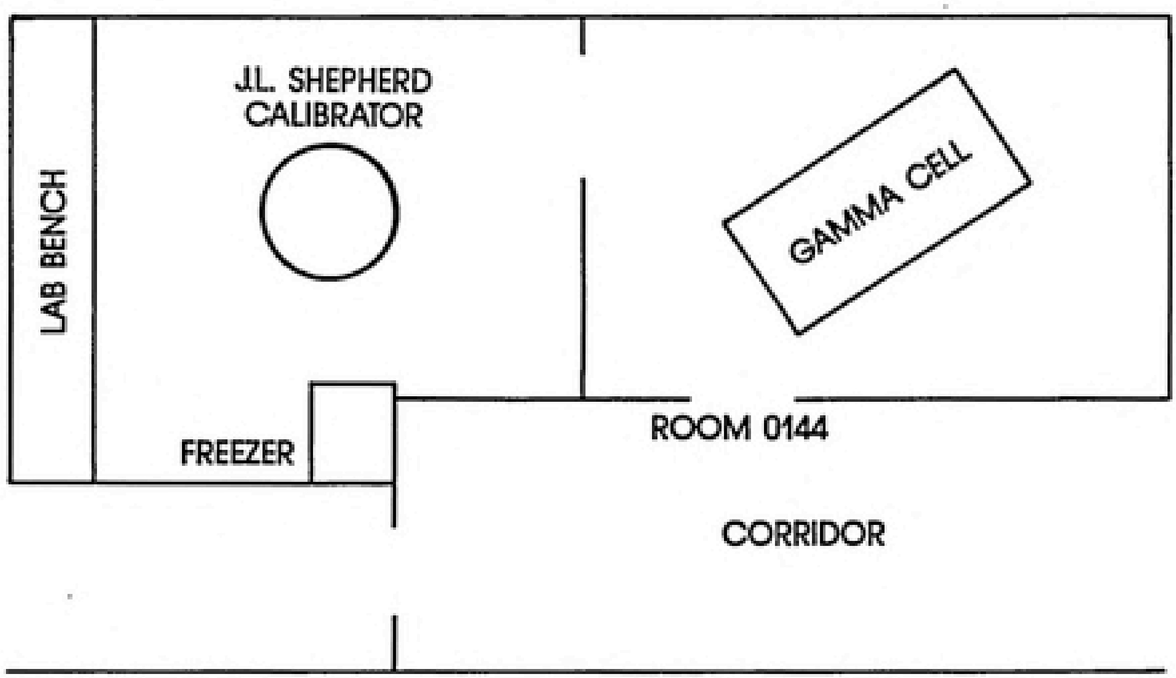


Figure 4
BURROUGHS WELLCOME CO.
Radiation Protection Department
Calibration Facility
South Building



C) Proper Shielding from Unwanted Radiation

Any radionuclides that have to be stored in the laboratory are shielded from the Panasonic UD-710A Automatic Reader. To ensure that background radiation does not affect the TLD reader, the area around the reader must be monitored before badge processing is attempted. The radiation level must not exceed background. If it is greater than background the source of the unwanted radiation must be found and reduced before badge reading occurs.

D) Standard Environment Controls

Temperature and humidity are held constant throughout the buildings. The laboratory is monitored with wipe test and instrument before any badge reading to ensure contamination and radiation levels are nominal. The laboratory and Calibration Facility are kept clean and free of dust.

E) Safety System

The laboratory has all fire and safety apparatus required by OSHA. After business hours, the facility is locked and can be opened by authorized personnel. The Calibration Facility also meets all OSHA requirements. Authorized entry is only granted by the Radiation Protection Department.

F) Standard Calibrated Equipment for Determining Dose

The J. L. Shepherd Model 28-5D Calibrator is used to irradiate badges to known doses. This instrument contains a 120 mCi Cs-137 source. The radiation field is accurately measured with an ionization chamber with calibration traceable to the National Bureau of Standards. The Panasonic UD-710A Automatic Reader is calibrated every six months by the Staff Specialist and serviced by Panasonic at least once a year. Calibration is required after any maintenance or repair.

G) Emergency Backup Procedure

If the Panasonic Reader malfunctions and the Staff Specialist cannot rectify the problem, the Panasonic sales representative is called and the problem is normally handled within two days. Due to the nature of work done at Burroughs Wellcome Co. (low level exposures), daily reading of dosimeters is not needed. Therefore a two day wait does not hinder the Company nor the safety of personnel. Calibration is required after any machine repair.

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY CALIBRATION AND

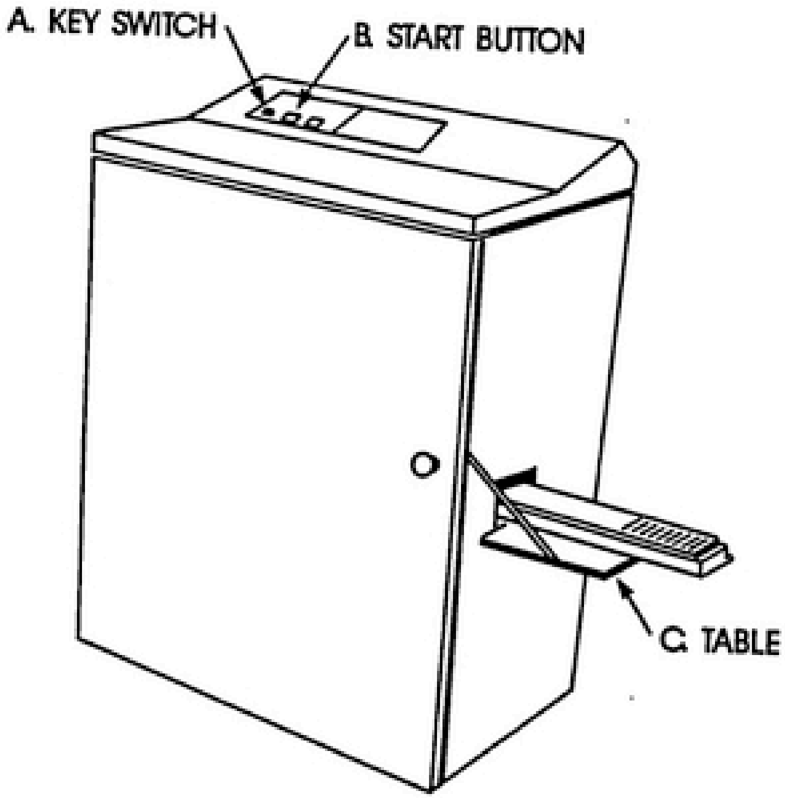
PROCESSING EQUIPMENT INVENTORY

Equipment used in the evaluation of dose to personnel at Burroughs Wellcome Co. is:

A) Panasonic UD-710A Automatic TLD Reader

This instrument is designed to measure the exposure of TLDs with good reproducibility and high speed (Figure 5). Basic operation involves optical heating to liberate energy stored in the traps of the thermo-luminescent (TL) material. When the TL phosphors are heated, electrons return to their ground states from the excited states induced by exposure to radiation. In returning to these ground states photons of light are liberated from the phosphor; hence the term thermo (heat) luminescence (light emitting). A tungsten lamp (heat source) flashes three times in the reading of each phosphor. The first flash is a pre-heat flash, which is followed by the TL phosphor reading flash, and then the post-annealing flash. The reader takes all pulse counts and converts them into a unit of exposure. This signal is sent to the in-house interactive computer system where it is converted to dose (mrems) and used to process dose reports.

Figure 5
UD-710A Automatic TLD-Reader



B) <u>Panasonic UD-801 TLD</u>

It contains two elements of $L_2B_4O_7$:Cu (abbreviated LiBO) under 14 and 300 mg/cm^2 of plastic and two replicate elements of $CaSO_4$:Tm (abbreviated CaSO) under 1000 mg/cm^2 of plastic and lead (Table 1). These are nominal filter thicknesses which include the filtration provided by the TLD hanger. The two LiBO elements are intended to measure shallow and deep doses, respectively. The two CaSO elements are available for checks of the deep dose. Since CaSO produces about twenty-five times more light per unit dose than does LiBO, it is more desirable to use CaSO than LiBO for frequent readings of small doses.

C) <u>Panasonic UD-815 TLD</u>

This dosimeter is used for automatic calibrations of the UD-710A Automatic TLD Reader (see DSOP 7, Calibration of the UD-710A Automatic TLD Reader) (Table 2). It contains no elements in positions 1 and 2 (usually used for LiBO), and it contains two replicate elements of CaSO in positions 3 and 4. These elements are both encapsulated in 300 mg/cm^2 of plastic.

D) <u>Panasonic UD-854A TLD Hanger</u>

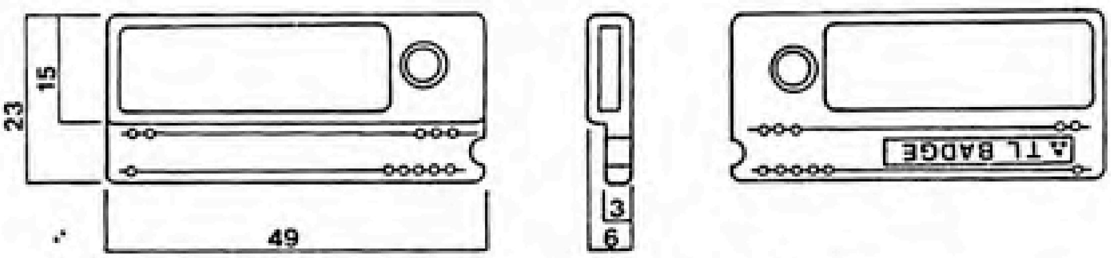
This is an open hanger for one badge (Table 3). It has an open wall thickness for element 1 and 160 mg/cm^2 wall thickness for element 2, 3, and 4. The hanger has a clip for attaching the device and is clear with a slight smokiness.

Table 1

BURROUGHS WELLCOME CO.
Radiation Protection Department

MODEL SPECIFICATIONS
TL Badge: UD-8O1 group

1. Model number	: UD-801-AQ, UD-801AR, UD-801AS
2. Use	: Personnel monitoring
3. Applicable reader	: UD-710A
4. Appearance	: See figure below
5. Element and shield composition	: See table below
6. Measurable rays and range	: $\gamma \cdot x$ rays (10keV~10MeV) 1 mrem~1000rem β rays (0.5MeV~4MeV) 10rem~1000 rem (Measurable range is in the case where single kind of rays is measured.)
7. Recommended hanger	: UD-854A
8. ID number	: Specified serial numbers (7 digits at maximum) are punched.
9. Label	: The labels shown in figure are sticked.



Appearance of TL Badge: UD-801AQ
(Badge measurements are in millimeters)

Element and shield composition of TL Badge
UD-801 group

Element	Phosphor	Shield*
E1	$Li_2B_4O_7$(Cu)	Plastics 14 mg/cm²
E2	$Li_2B_4O_7$(Cu)	Plastics 160 mg/cm²
E3	$CaSO_4$(Tm)	Lead 0.7 mm thick
E4	$CaSO_4$(Tm)	Lead 0.7 mm thick

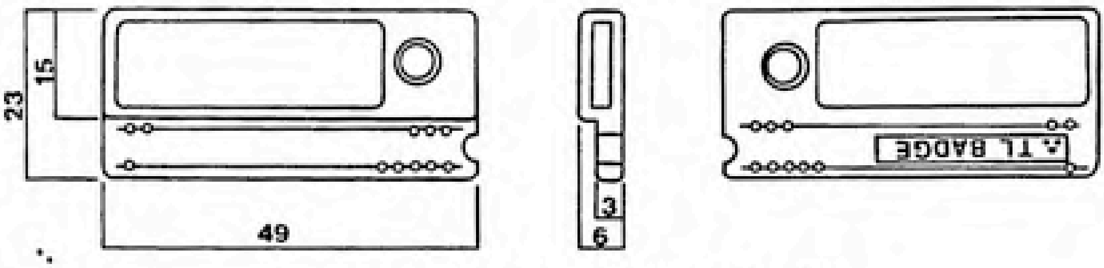
*The thickness of the hanger is not included. To obtain the total thickness when the badge is placed in the hanger, refer to the specifications of the hanger and add that thickness for each element.

Table 2

BURROUGHS WELLCOME CO.
Radiation Protection Department

MODEL SPECIFICATIONS
TL Badge: UD-815A group

1. Model number : UD-815A
2. Use : Reader calibration
3. Applicable reader : UD-710A
4. Appearance : See figure below
5. Element and shield composition : See table below
6. Measurable rays : γ rays
   ^{60}Co-γ rays or ^{137}Cs-γ rays
7. Recommended hanger : UD-854A
8. ID number : Specified serial numbers (7 digits at maximum) are punched.
9. Label : The labels shown in figure are sticked.



Appearance of TL Badge: UD-815A
(Badge measurements are in millimeters)

Element and shield composition of TL Badge
UD-815A

Element	Phosphor	Shield*
E1	——	——
E2	——	——
E3	$CaSO_4$(Tm)	Plastics 160 mg/cm²
E4	$CaSO_4$(Tm)	Plastics 160 mg/cm²

*The thickness of the hanger is not included. To obtain the total thickness when the badge is placed in the hanger, refer to the specifications of the hanger and add that thickness for each element.

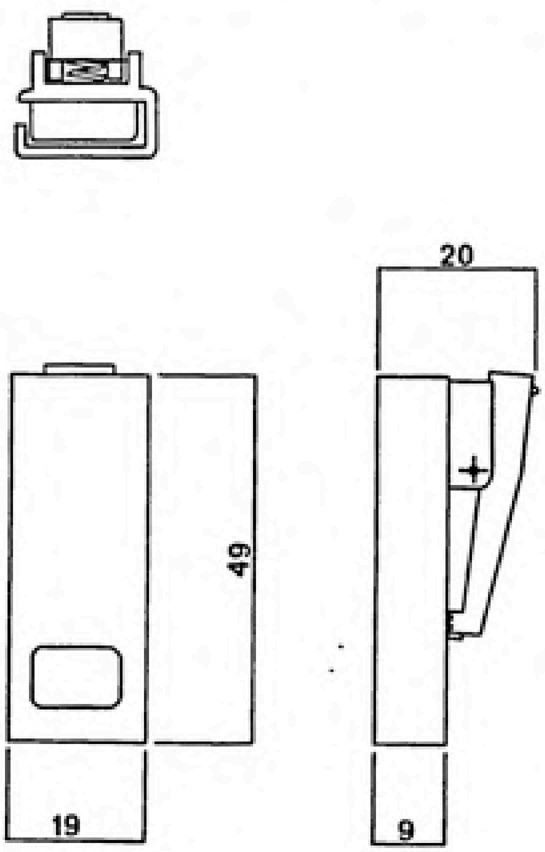
Table 3

BURROUGHS WELLCOME CO.
Radiation Protection Department

MODEL SPECIFICATIONS
TL Badge Hanger: UD-854A

1. Model number	: UD-854A
2. Type	: Open type for one badge
3. Applicable TL Badge (Examples)	: UD-801A, UD-815A
4. Appearance	: See figure below
5. Body material	: ABS resin
6. Front wall thickness	: For element 1 open For elèment 2 plastics 160 mg/cm² For element 3 plastics 160 mg/cm² For element 4 plastics 160 mg/cm²
7. Attaching device	: An aluminum clip
8. Color	: Clear with slight smokiness.
9. Weight	: Less than 4 grams

Structure of hanger: UD-854A
(Badge Hanger measurements are in millimeters)



E) Panasonic UD-740 Magazine

It is a black, plastic holder of TLDs (Figure 6). Badges are placed in the magazine, making sure there is uniformity in the direction of the badges. Fifty badges can be mounted in a magazine. The magazine allows processing of many badges (up to 50) at one time instead of feeding the reader each individual badge manually.

F) J. L. Shepherd Model 28-5D Calibrator

It consist of a 120 mCi Cs-137 source and an attached calibration table for irradiating thermoluminescent dosimeters to precisely known and reproducible gamma dose levels (Figure 7).

G) Victoreen Model 570 Condenser R-Meter

It consists of an a.c. operated d.c. power supply, a complete dust-tight electrometer with its viewing microscope system, a lighting system for the microscope and the "ON-OFF" indicating light, and necessary operating controls (Figure 11). All are contained in a metal case. Projecting from the top of the case are the two operating controls and the viewing microscope. The Condenser R-Meter is used with interchangeable ionization chambers. This instrument has calibration directly traceable to the National Bureau of Standards (NBS).

Figure 6
Panasonic UD-740 Magazine

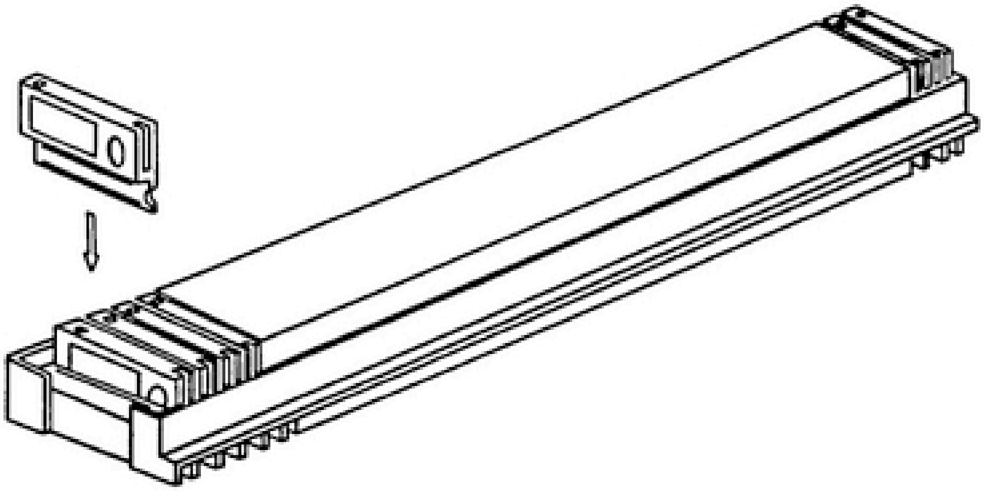


Figure 7
J.L. Shepherd Model 28-5D Calibrator

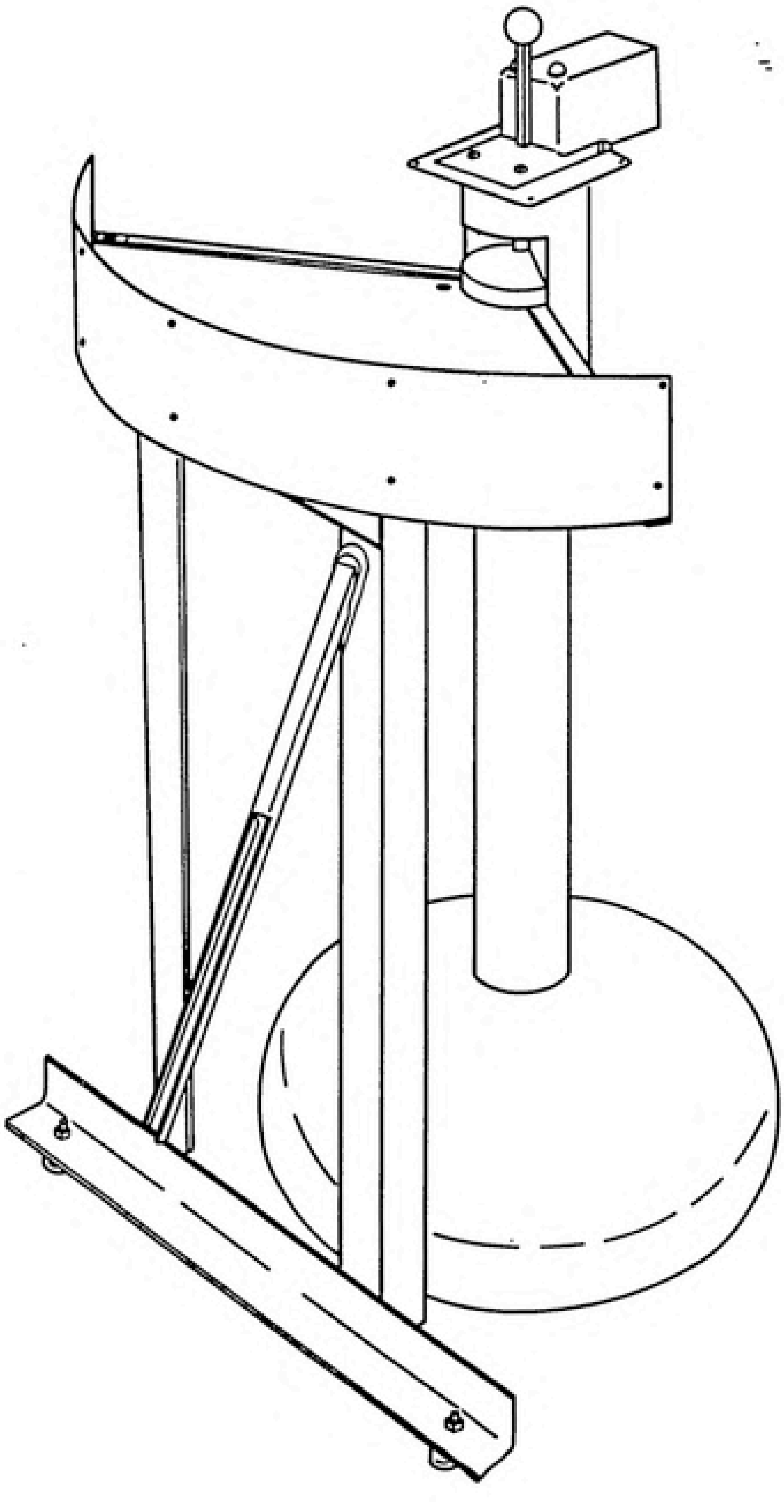
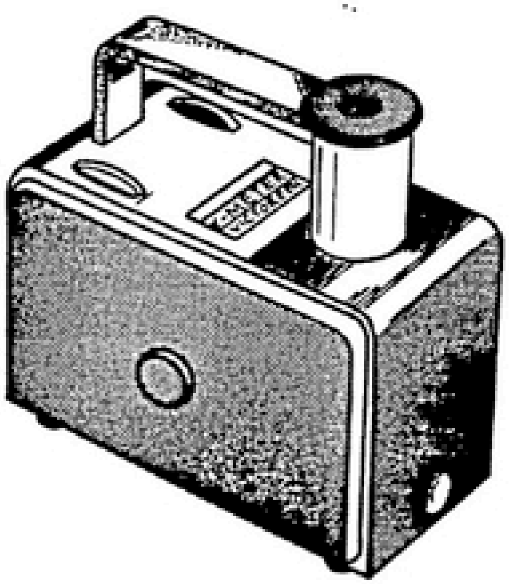


Figure 11



Model 570
Condenser R-Meter

Storage of the instruments:

When not in use the TLD Reader is kept in the Radiation Protection Department Laboratory. The laboratory is maintained at a standard temperature and humidity. Also, the laboratory is kept dirt and dust free by weekly janitorial maintenance.

It is not desirable to put the TLD in a high temperature and high humidity environment for a long period of time. It is recommended, ideally, to store TLDs in a desiccator containing desiccant as drying agent. The TLD does not have a definite storage time limit as does a film badge. However, the TLD is subjected to natural radiation even when not used. Before using such a badge, it should be annealed to eliminate the accumulated dose from natural radiation.

The Calibrator is stored in the South Building. The environmental conditions are kept constant throughout the building. Access to the Calibrator is controlled by the Radiation Protection Department.

Hangers and Magazines are stored in a lab bench in the Radiation Protection Department Laboratory.

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

TLD SHIPMENT ACCEPTANCE, VERIFICATION, AND STORAGE

DSOP 1

I. Purpose

This procedure establishes a standard method of accepting, verifying, and storing TLD materials.

II. Responsibility

A. This procedure covers all new TLDs, new hangers, and any other dosimetry related equipment.

B. This procedure applies to the Staff Specialist of the Radiation Protection Department.

III. Materials and Equipment

Desiccator cabinet

Desiccant

Laboratory storage boxes

IV. Summary

Over time, TLD components may wear due to use and age. Periodically it is necessary to purchase new TLD equipment (TLDs, hangers, etc.) to replace worn equipment and to keep inventory levels up. When new materials are shipped to Burroughs Wellcome Co. the items must be accepted, verified, stored, and properly documented.

V. Prerequisites

Whenever total inventory levels fall below 800 UD-801 TLDs, 30 UD-815 TLDs, or 800 UD-854 Hangers, a purchase order is approved and sent to the Panasonic Company. Any other TLD materials deemed necessary for use or emergency inventory will also be ordered.

VI. Acceptance

A. When ordered materials arrive at Burroughs Wellcome Co., the Receiving Department will send all packages to the Radiation Protection Department. The order will be accompanied by a receiving ticket and accounts payable ticket.

B. Upon acknowledgement that the correct number of packages has arrived, the Radiation Protection Department will accept the packages and sign the receiving ticket.

VII. Verification

A. Once received, the packages are opened in the laboratory.

B. Each item is carefully examined to ensure no observable damage from shipment. TLDs should be opened to visually verify the phosphors are correct and not damaged.

C. TLDs must be annealed according to DSOP 2 and quality control tested according to DSOP 3 before being used for dosimetry.

D. Upon completion of verification, the accounts payable slip is signed granting payment.

VIII. Storage

A. All new materials must be kept in the Radiation Protection Department Laboratory. The room is maintained at a constant temperature and humidity.

B. The lab is monitored and cleaned weekly.

C. All extra TLDs should be stored in a desiccator cabinet containing desiccant as drying agent.

D. The TLD does not have a definite storage time limit as does a film badge. However, the TLD is subjected to natural radiation even when not used for a long period of time. Before any badge is put in-service, annealing must be done in accordance with DSOP 2 to eliminate the accumulated response to natural radiation.

E. TLDs, hangers, and any other new materials shall be kept in the laboratory storage benches designated for TLD materials.

IX. Frequency

A. Inventory records must be updated every year or when new materials are added or subtracted from the current inventory.

B. DSOP Form 1 must be filled out in either case.

X. Records

A. Current inventory status must be updated by filling out DSOP Form 1.

B. The current inventory status must be kept until a new inventory count is required.

BURROUGHS WELLCOME CO.
Radiation Protection Department

TLD INVENTORY

CURRENT TLD INVENTORY

	Currently Issued (1)	On-Hand (2)	Total (3) (1 & 2)
UD-801 TLDs	______	______	______
UD-815 TLDs	______	______	______
UD-854 Hangers	______	______	______
UD-740 Magazine	______	______	______
(Other) ______	______	______	______
(Other) ______	______	______	______

NEW TLD INVENTORY

	Received (4)	Total (5) (3 & 4)
UD-801 TLDs	______	______
UD-815 TLDs	______	______
UD-854 Hangers	______	______
UD-740 Magazine	______	______
______	______	______
______	______	______

Date Shipment Received: ______ Date Shipment Verified: ______

Visual ______

Anneal ______

Quality Control ______

Performed by: ______ Date: ______

Reviewed by: ______ Date: ______
CRSO

DSOP Form 1

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

PREPARATION OF THERMOLUMINESCENT DOSIMETERS BEFORE FIELD USE

DSOP 2

I. Purpose

This procedure establishes a standard method for preparation of personnel thermoluminescent dosimeters (TLDs) before field use.

II. Responsibilities

A. This procedure covers preparation of personnel TLDs, background control badges, calibration check badges, calibration check background badges, and any new TLDs put into service for the first time.

B. This procedure applies to the Staff Specialist in charge of dosimetry services.

III. Materials and Equipment

Panasonic UD-710A Automatic TLD Reader

Panasonic UD-801 TLDs

Panasonic UD-815 TLDs

Panasonic UD-854A Hangers

Texas Instrument Silent 700 Printer

Badge Labels

IV. Summary

TLDs respond to background radiation when not in field use. To zero TLDs before putting them into service they must be annealed. This instruction also allows the Staff Specialist to prepare all the necessary TLDs for calibration and field issue used throughout the monitoring period.

V. Prerequisites

A. All calibration TLDs will be irradiated with a J. L. Shepherd Model 28-5D Calibator using a standard Cs-137 source. Prior to irradiation, the radiation exposure rate must be measured if the radiation level at the selected distance has not been verified by measurement within the last six months. All Radiation Field Measurements and Calibration Irradiations will be made in accordance with DSOP 8.

F. Select all the UD-815 TLDs when automatic calibration of the TLD reader is required. Label each badge with "Auto. Cal.".

G. Load all the badges into magazines and anneal by reading in the BADGE SERVICE MODE on the UD-710A Automatic Reader. Retain and record the hard copy of the anneal data from the printer noting the number of badges annealed and the date.

H. Verify that all badges were properly and completely annealed by reviewing the printout.

1. A "D-5" error indicates a high postanneal readout and incomplete badge annealing. Reanneal badges with a D-5 error. If D-5 error occurs again, remove the badge from service.

2. "EEEE" indicates an element was not annealed at all and may be associated with a number of different error codes. Badges in which any element is not annealed shall be reannealed. If a badge again fails to have all elements annealed, remove the badge from service.

I. Complete Preparation of TLD Badges, DSOP Form 2.

VII. Irradiation of Calibration Check Badges

A. Load each dosimeter to be irradiated into a UD-854A hanger.

B. Operate the J.L. Shepherd Calibrator in accordance with DSOP 8, Radiation Field Measurements and Calibration Irradiations.

C. Irradiate 10 calibration check badges to 500 mrem to test the photon counter and 10 calibration check badges to 4000 mrem to test the frequency counter. This ensures that both counters are activated and functioning properly.

D. Select an irradiation time based on the exposure rate at the selected distance which will produce the desired dose. Since the source is standardized in terms of exposure in free air (R/hr), the exposure rate must be multiplied by a conversion factor of 1.03 to obtain the deep-dose equivalent rate (rem/hr).

E. Mark each badge with the anneal date, irradiation date, and irradiation dose.

F. After irradiating and marking the badges, complete Irradiation Calibration Check Data section of DSOP Form 2 and record the irradiation dose and date for each irradiated badge on the anneal printout.

VIII. Verification of Irradiation

A. Remove one badge from each irradiation group (500 mrem and 4000 mrem). Wait at least 24 hours, read each badge, and record Element 2 and Element 3 results on DSOP Form 2 under the Irradiation Verification section.

B. Calculate and record the percent difference between the irradiated value and the measured value for Element 2 and Element 3. If the percent difference of Element 2 or Element 3 exceeds ± 15%, notify the Corporate Radiation Safety Officer who will specify corrective action.

IX. Frequency

A. The annealing of badges shall take place, prior to badge use, or whenever an anneal date has expired ten days.

B. Annealing of new monthly dosimeters shall take place between ten and three days before issuance.

C. Irradiated calibration check TLDs should be done monthly and read before any badges are processed.

X. Records

A. Attach the printout of annealed TLDs, irradiation values of calibration check TLDs, and background control TLDs results to DSOP Form 2 and forward to be Corporate Radiation Safety Officer for review.

B. DSOP Form 2 and attached printouts will be retained for thirty years.

BURROUGHS WELLCOME CO.
Radiation Protection Department

PREPARATION OF TLD BADGES

Anneal Date: __________ Number of Badges Annealed: __________

Badge Number: __________ Through __________

IRRADIATION CALIBRATION CHECK DATA

Date Measured	Source Data CS-137 Activity	Strength R/hr	Number Badges	Dose (mrem)	Irradiation Date	Distance (cm)	Actual Time (min)
				500			
				4000			

IRRADIATION VERIFICATION

TLD Badge Number	Irradiation Value (A) (mrem)	E_2 (mrem)	E_3 (mrem)	E_2 % Diff	E_3 % Diff
	500				
	4000				

$$E_2 \text{ \% Diff} = \frac{E_2 - A}{A} \times 100 \qquad E_3 \text{ \% Diff} = \frac{E_3 - A}{A} \times 100$$

Note: If percent difference of Elements 2 or 3 exceeds ±15 percent, notify the CRSO

Performed by: ______________________________ Date: __________

Reviewed by: ______________________________ Date: __________
CRSO

DSOP Form 2

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

QUALITY CONTROL TESTING OF THERMOLUMINESCENT DOSIMETERS

DSOP 3

I. Purpose

This procedure establishes a standard method for quality control testing of thermoluminescent dosimeters (TLDs).

II. Responsibilities

A. This procedure covers the testing of all TLDs for personnel monitoring.

B. This procedure applies to the Staff Specialist of the Radiation Protection Department.

III. Summary of Method

All personnel dosimeters must be tested periodically to ensure they are the proper model (newly received badges only) and they are functioning properly. All personnel TLDs are irradiated in badge hangers placed on the J. L. Shepherd Calibrator, which uses a Cs-137 source. The radiation field used is accurately measured with ionization chambers with calibration traceable to the National Bureau of Standards. After irradiation, TLDs are read on the Panasonic TLD Reader and the readings are compared to the acceptance limits. The test results, date checked, and validity status for all badges is documented. Badges outside of acceptance limits are removed from service.

IV. Materials and Equipment

Panasonic UD-710A Automatic TLD Reader

Panasonic UD-801 TLDs

Panasonic UD-854A Badge Hangers

J. L. Shepherd Model 28-5D Calibrator

Texas Instrument Silent 700 Printer

V. Criteria

A. Each element within a badge must read within ± 15 percent of the irradiation value.

B. If any badge element differs by more than ± 25 percent from the irradiated value, an investigation shall be performed to determine if dose measurements made since the last quality control test are acceptable.

C. Each element must have no greater than 4 percent residual dose upon second reading after irradiation.

VI. TLD Irradiation

A. Measure the radiation exposure of the J. L. Shepherd Calibrator as specified by Dosimetry Standard Operating Procedure 8 if the field has not been measured within the last six months at the same point.

B. Anneal all dosimeters for testing prior to irradiation in accordance with Dosimetry Standard Operating Procedure 2.

C. Place the Panasonic UD-801 TLDs in Panasonic UD-854A Hangers and clip them to the calibration table of the J. L. Shepherd Calibrator.

D. Position fifteen badges at the desired distance (60 cm preferably) and place the calibration phantoms directly behind these badges. Do not allow any badge to be within two inches of the edge of the phantom.

E. Irradiate the Panasonic UD-801 TLDs for a length of time that will produce a 500 mrem exposure.

F. Document the irradiation data on Quality Control Exposure Record Form 3.

B. The residual dose must be no greater than 4 percent of the radiation dose on each element.

C. Badges with greater than 4 percent residual dose shall be tested one more time before being removed from service.

D. Attach the printout of residual dose readings to the Quality Control Test Record for TLDs.

IX. Reassignment of Failed Badges

A. For badges which fail the quality control or residual testing, deassign the failed badge if in use and reassign a new one.

B. Remove the old label from the failed badge and place this badge with the other badges removed from service.

X. Frequency

A. All new personnel TLDs shall be tested for quality control purposes before they are allowed to be put in service.

B. All personnel TLDs shall be retested every six months.

XI. Records

A. Attach the Quality Control Exposure Record, DSOP Form 3, all printouts of test results, a list of failed badges, and the residual dose results to the Quality Control Test Record for TLDs, DSOP Form 4.

B. Complete and submit the Quality Control Test Record for TLDs, DSOP Form 4 to the Corporate Radiation Safety Officer for approval.

C. All TLD quality control results shall be retained permanently in the dosimetry files at the Radiation Protection Department.

BURROUGHS WELLCOME CO.
Radiation Protection Department

QUALITY CONTROL EXPOSURE RECORD

Magazine Number	Dosimeter No. Start	End	Source (Ci)	Distance (cm)	Exposure Time (Min)	Exposure Rate (R/hr)

Date: ____________________

Time Started: ____________________ Time Completed: ____________________

Performed by: ______________________________ Date: ______________

Reviewed by: ______________________________ Date: ______________
CRSO

DSOP Form 3

BURROUGHS WELLCOME CO.
Radiation Protection Department

QUALITY CONTROL TEST RECORD FOR TLDs

Date: ________________ Irradiation Dose: ________________

Badge Type: ________________ Type Test: Routine or Special

Explain if Special Test: ____

____

Total number of badges tested : ________________

Number badges passed : ________________

Number that failed sensitivity test : ________________

Percent failing sensitivity test : ________________%

Number that failed residual test : ________________

Percent failing residual test : ________________%

Attachments: Quality Control Exposure
Badge Test Printouts
List of Failed Badges

Performed by: ______________________________ Date: ________________

Reviewed by: ______________________________ Date: ________________

Approved by: ______________________________ Date: ________________
CRSO

DSOP Form 4

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

READING OF THERMOLUMINESCENT DOSIMETERS

DSOP 4

I. Purpose

This procedure establishes a standard method for reading thermoluminescent dosimeters (TLDs).

II. Responsibility

A. This procedure covers the reading of TLDs for personnel monitoring using the Panasonic UD-710A Automatic TLD Reader.

B. This procedure applies to the Staff Specialist in charge of dosimetry services.

III. Summary of Method

Periodically it is necessary to read TLDs in order to determine personnel dose. The Staff Specialist must first verify certain machine parameters are set correctly. A calibration check of the reader must then be performed to ensure the reader is functioning correctly. Upon verificaion that the reader is operating properly, the Staff Specialist shall determine the background dose and enter it into the reader. Once accomplished, the actual reading of TLDs and evaluating of the data are performed. This procedure also incorporates cleaning of the TLD readers optical block if it is necessary.

IV. Equipment and Materials

Panasonic UD-801 TLDs

Panasonic UD-710A Automatic TLD Reader

Texas Instrument Silent 700 Printer

V. Prerequisites

A. The Panasonic UD-710A Automatic TLD Reader shall be calibrated and the calibration shall be in date in accordance with DSOP 7.

B. The Staff Specialist who operates the TLD reader shall be qualified in accordance with DSOP 11.

C. All badges shall be surveyed for contamination. A reading of greater than 100 cpm above background shall require notification of the Corporate Radiation Safety Officer.

D. TLDs which are wet shall be dried in a dessicater for at least 12 hours prior to reading.

VI. Precautions and Limitations

A. The background dose used for correction of personnel TLD readings shall not exceed 15 mrem for monthly badges.

B. The average background-corrected TLD reading during calibration checks shall be within ± 15% of the known irradiation exposure.

VII. Operating the Panasonic UD-710A Automatic TLD Reader

A. Initial Instrument Setup

1. Always allow a 30 minute warm-up time before reading TLDs.

2. Select the READER CHECK mode with the key switch and depress the MODE key until DISPLAY MODE appears on the display panel. Set FIX to 1.

3. Depress MODE key until PROCESS MODE is displayed, and set READER COR, BADGE COR, and NCR PARITY to 1.

4. Depress MODE key until RS-232C MODE is displayed, and verify that RS-232C MODE is set to 1 for NO DATA LINK. This will ensure the computer is used.

5. Depress MODE key until GP-IB MODE is displayed, and verify that the mode is set to 1.

6. Depress the PARAM key until REFERENCE LEVEL is displayed, and verify that the reference levels for Elements 1 and 2 are set at 500 mR. Five hundred milliroentgens will be compared to the measured doses for Elements 1 and 2 so that doses above those levels can be flagged on the output. BACKGND is the dose which is to be subtracted from the measured dose. The method of determining the value for the end-of-month or end-of-quarter background is outlined in this procedure.

7. Depress the PARAM key until READER CODE is displayed, and verify that reader code is 20 and the ELEMENT is 1111. ASSIGNMENT for TL BADGE is set to 7FFF for reading Panasonic UD-801 TLDs.

8. Depress the PARAM key until CONVERSION COEF is displayed, and verify that conversion coefficients for Photon Counter (P), Frequency Counter (F), and CAL STD are the correct calculated values (see current calibration sticker).

9. Select the BADGE SERVICE mode with the key switch.

B. Calibration Check

1. Load a calibration check background TLD, a calibration TLD irradiated to 500 mrem and one irradiated to 4000 mrem.

2. Load the magazine directly into the reader.

3. With the reader in BADGE SERVICE mode, depress the START button on the reader. Badges will be read automatically and data transferred to the printer.

4. Using DSOP Form 5, TLD Reader Calibration Check Form, record the results. Calculate the difference in response between Element 2 and Element 3 to the irradiation dose.

5. The background corrected result of both calibration TLDs must be within $\pm$ 15% of the irradiated value for Element 2 and Element 3.

6. If the calibration check fails, perform cleaning of the optical block as outlined in this procedure.

7. Repeat the calibration check. If the calibration check fails again notify the Corporate Radiation Safety Officer for corrective action.

C. Background Determination

1. Load the four background control TLDs into a magazine.

2. Load the magazine into the reader.

3. With the reader in BADGE SERVICE mode, depress the START button. Badges will be automatically read and data transferred to the printer.

4. After the background control badges have been read, calculate the average readings for Elements 1 and 2 and record on DSOP Form 6, Background Determination Form.

5. The background dose used for correction of personnel TLDs shall be the lower of the Element 1 and Element 2 average TLD readings.

D. Setting the Background Reference Level on the Reader

1. Select the READER CHECK mode with the key, and depress the PARAM key until REFERENCE LEVEL is displayed.

2. With the cursor shift keys, position the cursor to BACKGND and enter the background dose calculated above.

3. Depress the ENTER key to store the value in memory.

4. Return to BADGE SERVICE mode.

5. Submit the Background Determination Form to the Corporate Radiation Safety Offices upon completion of the reading.

E. Reading TLDs

1. Before reading TLDs, contact the computer. Put the computer keys to LOGON-LOGOFF.

2. Hit "!" on printer and wait for a cue. Type in RSO1 space TLD and some other identifier (use a 1 or 2). Press the RETURN key on the printer.

3. Wait for File Name and Date.

4. Change all switches to DATA. Computer is now accepting data from TLD readings.

5. Load the TLDs into magazines.

6. Load one magazine at a time into the reader.

7. With the TLD Reader in BADGE SERVICE MODE, depress the START button on the reader. The TLDs will automatically be read and the data transferred to the computer and printer.

8. When the loaded TLDs have been read, an alarm will sound. Unload the magazine and repeat the above steps until all badges are read.

9. If an error occurs that interrupts the operation of the reader, the reader alarm will sound and an error message will be displayed. Refer to the Internal Parameters section of the User's Manual for corrective action. Record the error and corrective action in the TLD LOG, DSOP Form 7.

10. If unable to correct an error, contact the Corporate Radiation Safety Officer for further instructions.

11. If a list of internal parameters is desired, select the READER CHECK mode with the key switch. Depress the PARAM button until PARAMETER appears. Press 2 and the ENTER key. The parameters will be automatically printed.

VIII. Review of TLD Readings

A. TLD readings shall be reviewed for unusual results (unusual element ratios) before updating dose records. This is accomplished by review of the printout provided by the printer.

B. If a reading appears to be unusual (any reading greater than 75 mR), an investigation shall be performed in accordance with DSOP 9 by the Corporate Radiation Safety Officer to determine if the badge readings are valid.

C. After an investigation or if all readings appear normal, update dose records in accordance with Appendix A.

D. Promptly notify the Corporate Radiation Safety Officer in the event of doses in excess of administrative limits:

Monthly penetrating:	> 200 mrem
Quarterly penetrating:	> 625 mrem
Yearly penentrating:	> 2500 mrem
Lifetime penetrating:	> 5000 * (employees age - 18) 500 mrem allowed for 18 yr olds
Monthly shallow:	> 2500 mrem
Quarterly shallow:	> 7500 mrem
Yearly shallow:	>30,000 mrem

IX. Cleaning the Panasonic UD-710A Automatic TLD Reader Optical Block

A. Turn the reader power off with the key switch.

B. Open the front panel with the key and raise the top panel as shown in Figure 8.

C. Switch circuit breaker NFB to OFF position.

D. Disconnect circuit breakers (1), (2), and (3) (Figure 9).

E. Loosen the housing mounting screws, the PMT housing support mounting screw, and pull the PMT housing out straight in Direction B while holding it to separate the subhousing from the main housing. For smoother removal, pull the PMT housing support straight in Direction B (Figure 9). Do not apply excessive force.

F. Remove the heating lamp power socket (Figure 10).

G. Loosen the heating lamp assembly set screws, and carefully remove the heating lamp assembly (Figure 10).

H. Remove the heating lamp assembly set screws.

I. Remove screw "a" and then remove the lamp retainer, O-ring, heating lamp, and filter retainer (Figure 10).

J. Place a soft, clean, dry cloth, or tissue over the infrared filter in the convergence tube; place hand on top, tilt the convergence tube over, and catch the infrared filter in the cloth or tissue.

K. Place the infrared filter in a secure location.

L. Clean the inside of the convergence tube with a soft, clean, dry tissue, cloth, or cotten swab.

M. Clean the infrared filter with a soft, clean, dry cloth, or tissue without putting fingerprints on the filter.

N. To place the infrared filter back into the convergence tube, hold the filter in the palm of the hand on top of the cloth, place the inverted convergence tube over the filter, and tilt the convergence tube and filter together back to the upright position, reposition the infrared filter in the bottom groove if necessary.

O. Place the filter retainer ring with the notched side up on top of the infrared filter.

P. Using a soft, clean, dry cloth, reposition the filter retainer until the "U" shape groove is over the pin in the convergence tube.

Q. Align the tab on bottom of the heating lamp with the notch in the infrared filter retainer ring, and place the heating lamp on the retainer ring. When reassembling the heating unit, the tab on the heating lamp must be in the notch on the filter retainer or damage to the bulb will result.

R. Replace the O-ring.

S. Replace the lamp retainer ring and align the holes for the screws over the appropriate screw holes.

T. Replace and tighten screw "a" and place heating lamp assembly set screws in their holes in the heating lamp assembly.

U. Place the heating lamp assembly in a secure location.

V. Remove the card carrier from the main housing by lifting up on the engaging notch and pulling the slider toward the badge push-up unit (Figure 9).

W. Clean the inside surfaces of the housing assembly with a soft, clean, dry cloth, tissue, or cotton swab. A slight amount of high-grade alcohol may be used in order to remove heavy dirt or gum residue left from labels.

X. Clean the blue filter over the PM tube with a soft, clean, dry cloth, tissue or cotton swab.

Y. Clean the card carrier's surface with a soft, clean, dry cloth, tissue, or cotton swab. A slight amount of high-grade alcohol may be used in order to remove heavy dirt or gum residue from labels except on the reference light source cover.

Z. Push a cotton swab or a tip of the cloth or tissue through Hole 1 to ensure that the hole is clean (Figure 9).

AA. Replace the card carrier by sliding the back of the card carrier under the card carrier guide bearing and pushing toward the back of the reader.

BB. Replace the heating lamp assembly in the main housing using a slight twisting motion to ensure a correct and flat fit of the heating lamp assembly.

CC. While holding pressure on the heating lamp assembly, set both heating lamp assembly set screws; then tighten both screws.

DD. Align the subhousing on the housing guide bars and slide the housing flush with the other side (Figure 9).

EE. While holding pressure on the end of the PMT housing, securely seat both housing mounting screws and tighten both screws.

FF. Reconnect connectors (1), (2), and (3).

GG. Lower the top panel of the reader.

HH. Switch the circuit breaker NFB to ON position and close the front panel of the reader.

II. Turn the reader power on with the key switch.

JJ. Each time the reader is cleaned, log the proper data on the DSOP Form 7, TLD LOG.

X. Records

A. The following records shall be fowarded to the Corporate Radiation Safety Officer for review and retention:

* TLD Reader Calibration Check Form
* Background Determination Form
* TLD LOG
* TLD Readings from printouts

B. All records shall be kept for a period of not less than thirty years.

BURROUGHS WELLCOME CO.
Radiation Protection Department

TLD READER CALIBRATION CHECK FORM

Date: ________________ Previous Reader Calibration Date: ________________

Photo Counter Conversion Coefficient : ________________________ mrem/cts

Frequency Counter Conversion Coefficient : ________________________ mrem/cts

Badge Irradiation Date: ______________ Badge Anneal Date: ______________

TLD READINGS

	Background (B)	Irradiation Value 500 mrem (A)	Irradiation Value 4000 mrem (A)
Element 1	________	________	________
Element 2	________	________	________
Element 3	________	________	________
Element 4	________	________	________
E_2 % Difference		________%	________%
E_3 % Difference		________%	________%

$$E\ \%\ \text{Diff} = \frac{(E - B) - A}{A} \times 100$$

Note: If percent difference of Elements 2 or 3 exceeds ±15% notify the CRSO.

Performed by: ______________________________ Date: ______________

Reviewed by: ______________________________ Date: ______________
CRSO

DSOP Form 5

BURROUGHS WELLCOME CO.
Radiation Protection Department

BACKGROUND DETERMINATION FORM

Date: ______________________ TLD Anneal Date: ______________________

Previous Reader Calibration Date: ______________

TLD READINGS

TLD #	Element 1	Element 2
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
Average:	________	________
Final Value:	________	________

Performed by: ______________________________ Date: ______________

Reviewed by: ______________________________ Date: ______________
CRSO

DSOP Form 6

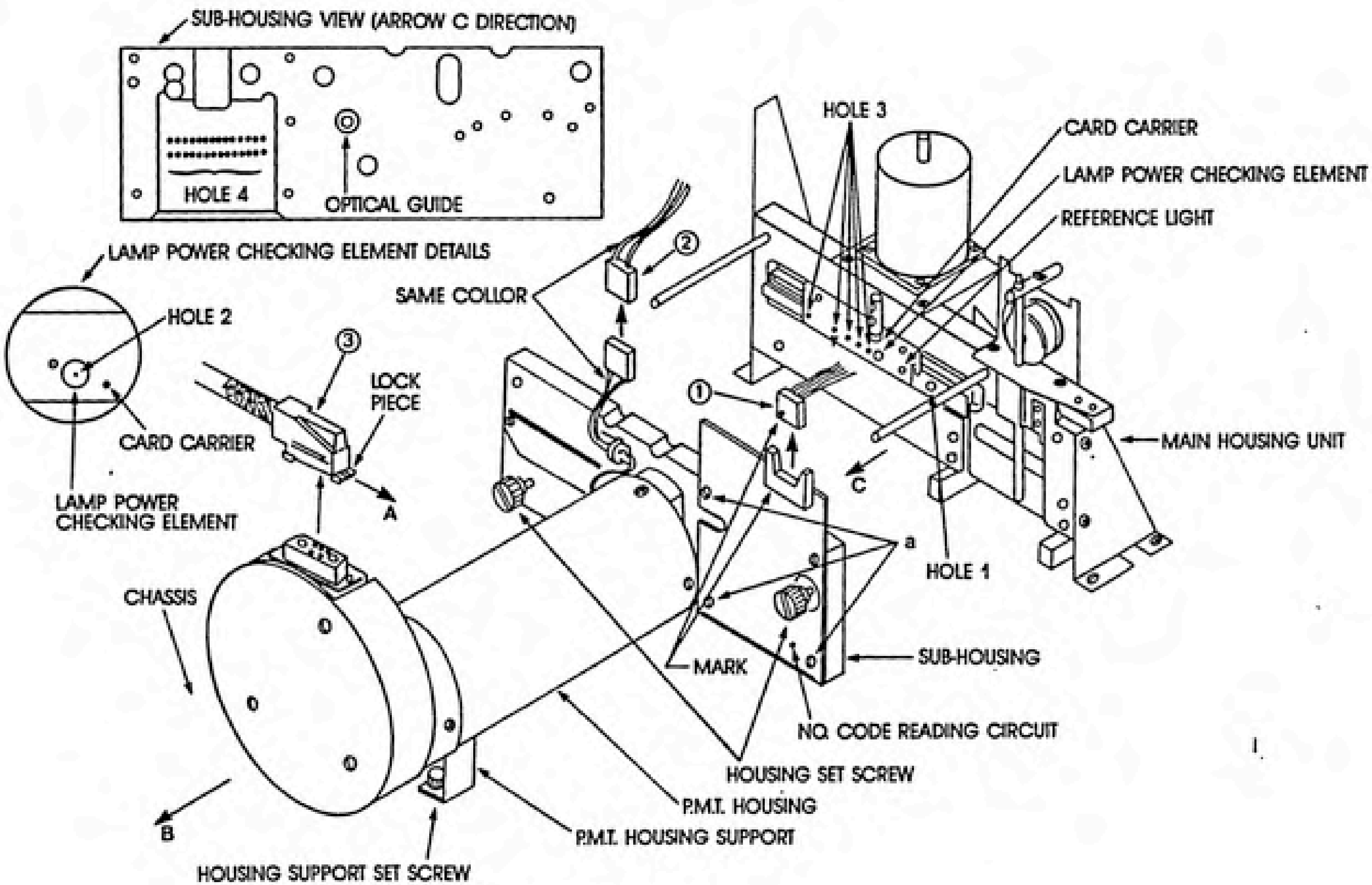
BURROUGHS WELLCOME CO.
Radiation Protection Department

TLD LOG

Date	Staff Specialist	Error Code	Slot No.	Corrective Action Taken	Comments

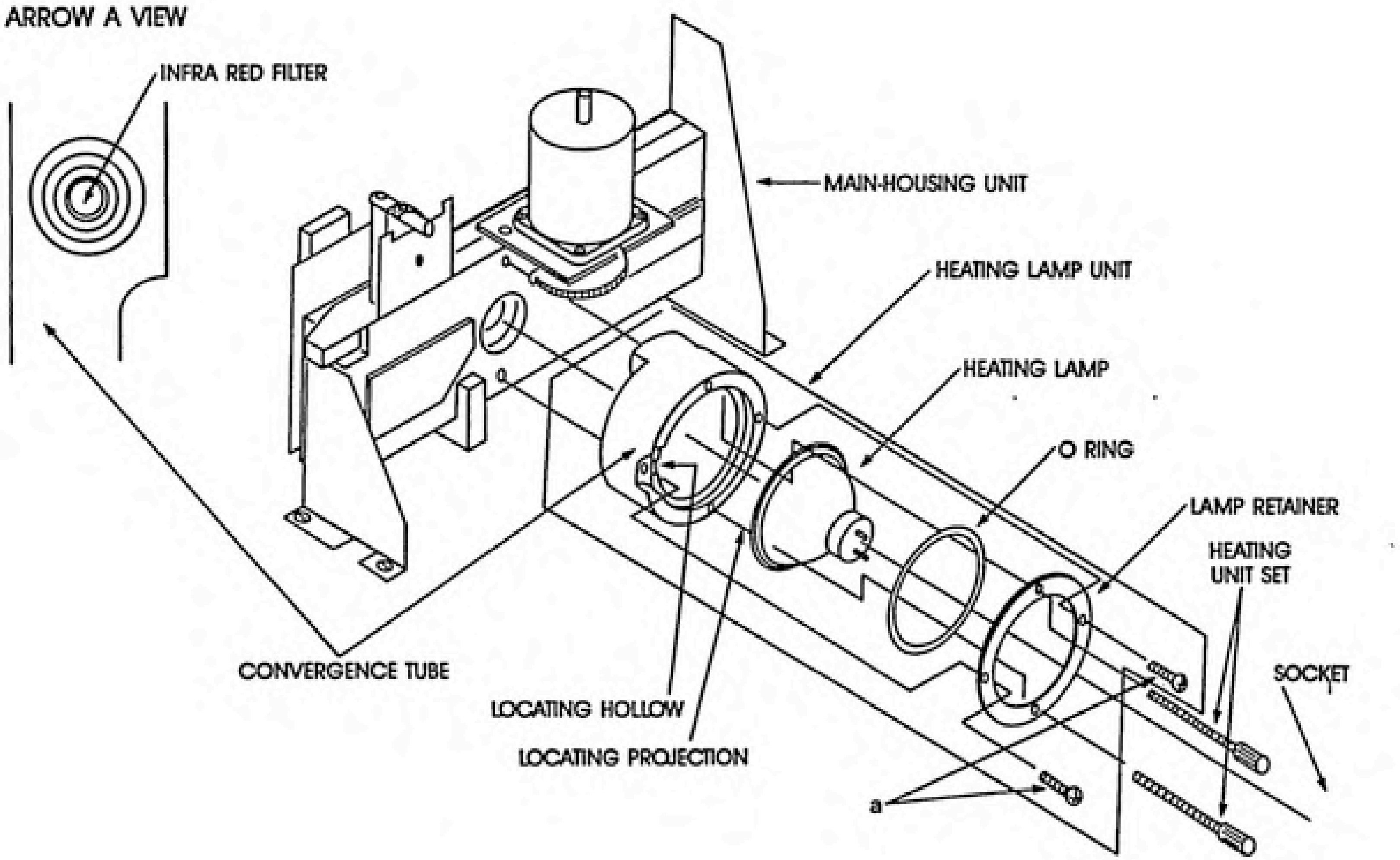
DSOP Form 7

FIGURE 9



SUB-HOUSING VIEW (ARROW C DIRECTION)
HOLE 4
OPTICAL GUIDE
LAMP POWER CHECKING ELEMENT DETAILS
HOLE 2
CARD CARRIER
LAMP POWER CHECKING ELEMENT
SAME COLLOR
②
③
LOCK PIECE
A
①
HOLE 3
CARD CARRIER
LAMP POWER CHECKING ELEMENT
REFERENCE LIGHT
MAIN HOUSING UNIT
C
a
HOLE 1
CHASSIS
MARK
SUB-HOUSING
NO. CODE READING CIRCUIT
HOUSING SET SCREW
P.M.T. HOUSING
P.M.T. HOUSING SUPPORT
B
HOUSING SUPPORT SET SCREW

Figure 10
Heating Lamp Unit



BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPATMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

DOSIMETRY ISSUANCE

DSOP 5

I. Purpose

This procedure establishes the method for issuing personnel dosimetry devices.

II. Responsibility

A. This procedure covers the initial issuance of routine whole body monitoring devices such as thermoluminescent dosimeters (TLDs).

B. This procedure applies to the Staff Specialist in charge of dosimetry services.

III. Prerequisites

A. An individual must be at least 18 years old to be issued dosimetry for occupational exposure monitoring.

B. All applicable radiation protection requirements, as stated in this procedure, must be met before the individual is issued dosimetry.

IV. Procedure

A. Occupational External Radiation Exposure History, Form RSO-8, must be completed for each person issued a TLD. All past exposures should have supporting documentation.

B. Upon completion, Form RSO-8 shall be reviewed by Radiation Protection Staff for completeness, accuracy, and legibility.

C. Any individual who needs to request past dose records from previous employers shall fill out Form USA 1473.

D. Upon completion, Form USA 1473 shall be reviewed by Radiation Protection Staff for completeness, accuracy, and legibility.

E. Form USA 1473 shall be mailed to any previous employers from which documentation is needed. A copy of the request is kept in a pending file in the Radiation Protection Department.

F. When a response is received, the dose history on Form RSO-8 will be completed or verified for the applicable exposure period.

G. If supporting documentation is not obtainable from the previous employers because insufficient information is provided or other valid reasons or if 60 days have elapsed without response to Form USA 1473, a second request is made.

H. An individual must submit to a bioassay and thyroid scan prior to issuance of a dosimeter. This information will be the basis for comparison evaluation of the internal radiation protection practices at Burroughs Wellcome Co.

I. Upon completion of the bioassay and thyroid scan, a Radiation Safety Handbook is issued to the individual. The individual is advised to read and follow all the guidelines set forth by the handbook.

J. The individual is then issued a valid badge. The individual's last name and badge identification number are written on the badge. The Staff Specialist picks the badge identification number from numbers that are currently available.

K. The Staff Specialist advises the individual as to the proper wearing of the TLD when in use and the proper storing of the TLD when not in use.

L. Necessary information is added to the Burroughs Wellcome Co. Occupational Dose-Equivalent Report by using the TLDADD program associated with the computer (see Appendix A).

V. Monthly - Quarterly Badge Issuance

A. All employees at Greenville, N.C. will be issued badges quarterly.

B. All laboratory support personnel at Research Triangle Park, N.C. will be issued badges quarterly.

C. All laboratory research personnel at Research Triangle Park, N.C. will be issued badges monthly.

VI. Records

A. Form RSO-8 and Form USA 1473 shall be held for permanent retention in the Radiation Protection Department.

B. The employee's dose equivalent report is kept on the computer record until notification of death, retirement, or termination. Upon leaving the Company, a hard copy of the individual's dose equivalent report is kept on file in the Radiation Protection Department.

RSO-8

Wellcome

THE WELLCOME RESEARCH LABORATORIES
Research Triangle Park, N.C. 27709

OCCUPATIONAL EXTERNAL RADIATION EXPOSURE HISTORY U.S.A. 1100

See Instructions on the Back

IDENTIFICATION

1. NAME (PRINT—LAST, FIRST, AND MIDDLE)	2. SOCIAL SECURITY NO.
3. DATE OF BIRTH (MONTH, DAY, YEAR)	4. AGE IN FULL YEARS (N)

OCCUPATIONAL EXPOSURE—PREVIOUS HISTORY

5. PREVIOUS EMPLOYMENTS INVOLVING RADIATION EXPOSURE—LIST NAME AND ADDRESS OF EMPLOYER	6. DATES OF EMPLOYMENT (FROM—TO)	7. PERIODS OF EXPOSURE	PREVIOUS DOSE HISTORY: 8. WHOLE BODY (REM)	PREVIOUS DOSE HISTORY: 9. RECORD OR CALCULATED (INSERT ONE)

10. REMARKS

11. ACCUMULATED OCCUPATIONAL DOSE—TOTAL	

12. CALCULATIONS—PERMISSIBLE DOSE

WHOLE BODY:

(A) PERMISSIBLE ACCUMULATED DOSE—5(N-18)— ....REM

(B) TOTAL EXPOSURE TO DATE (FROM ITEM 11)—..........REM

(C) PERMISSIBLE DOSE —..........REM

13. CERTIFICATION: I CERTIFY THAT THE EXPOSURE HISTORY LISTED IN COLUMNS 5, 6, AND 7 IS CORRECT AND COMPLETE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

EMPLOYEE'S SIGNATURE DATE

14. NAME OF LICENSEE OR REGISTRANT

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

DOSIMETRY EXCHANGE

DSOP 6.

I. Purpose

This procedure establishes the standard method for exchanging TLDs at the end of the monitoring period.

II. Responsibilities

A. This procedure covers the exchange of TLDs for all employees at the end of the specified monitoring period.

B. This procedure applies to the Staff Specialist in charge of dosimetry services.

III. Procedure

A. Issuance of new TLDs

1) Anneal all TLDs prior to issuance in accordance with DSOP 2, Preparation of TLDs Before Field Use.

2) Obtain envelope exchange labels by using BLABEL command on the computer. Put labels on exchange envelopes.

3) Put new monthly and quarterly badges (depending on the month involved) into Panasonic UD-854 hangers.

4) Verify that each person on Personnel Master List, DSOP Form 8, is issued a badge for the upcoming monitoring period. The Personnel Master List is kept up to date by the Staff Specialist.

5) Put the correct number and name badge in the corresponding labeled envelope. Scotch tape the envelope closed. Note: The return exchange envelope is included with this.

6) Put the exchange envelopes in the company mail.

7) This procedure is started and completed within the last three days of the month.

B. Return of old TLDs

1) Badges are required to be exchanged within 24 hours of receiving a new badge.

2) Badges are returned in the exchange envelope provided.

3) Mail room delivers all returned badges to the Radiation Protection Department.

4) Take badges out of envelopes.

5) Take badges out of hangers.

6) Sort badges numerically and put them into magazines.

7) Verify that all badges that went out came back in by using the Personnel Master List, DSOP Form 8.

8) If an employee fails to return a badge within 48 hours, that individual is contacted and the situation is rectified as soon as possible.

9) Once all badges are returned, reading of TLDs can be performed in accordance with DSOP 4, Reading TLDs.

IV. <u>Records</u>

Retain the Personnel Master List, DSOP Form 8, for a period of one year.

BURROUGHS WELLCOME CO.
RADIATION PROTECTION DEPARTMENT
PERSONNEL MASTER LIST

Badge	Employee												
		Out	In	Out	In	Out	In	Out	In	Out	In	Out	In

DSOP Form 8

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

CALIBRATION OF PANASONIC UD-710A AUTOMATIC TLD READER

DSOP 7

I. Purpose

This procedure establishes a standard method for calibration of the Panasonic UD-710A Automatic TLD Reader.

II. Responsibilities

A. This procedure covers the calibration of the Panasonic UD-710A Automatic TLD Reader for personnel monitoring.

B. This procedure applies to the Staff Specialist of the Radiation Protection Department.

III. Materials and Equipment

Panasonic UD-710A Automatic TLD Reader

Panasonic UD-801 Personnel TLDs

Panasonic UD-815 Calibration TLDs

Panasonic UD-854A TLD Hangers

J. L. Shepherd Model 28-5D Calibrator

Texas Instrument Silent 700 Printer

IV. Frequency

Calibration shall be performed at least once every six months or after any maintenance.

V. Summary of Method

TLDs are irradiated in standard personnel badge holders using a Cs-137 source. Personnel badges are placed in front of a polyethylene phantom during irradiation. The radiation field used is accurately measured with ionization chambers with calibrations traceable to the National Bureau of Standards. Calibration may be accomplished by two methods: verifying that the current parameters are correct and valid, and by performing an automatic machine calibration which calculates new parameters. Verifying current reader parameters calls for reading calibration check TLDs exposed to two different known dose levels and comparing the results (refer to DSOP 2); and if the results are within the acceptable range, validity verification can then be accomplished by reading verification badges irradiated as specified, and the results compared to acceptance criteria. Automatic calibration incorporates the reading of specific calibration badges, and based on pulse counts from badges irradiated to known doses, new conversion coefficients are calculated for the photon counting range and frequency counting range of the reader. The internal reader parameters for the photon counter range and frequency counter range are changed to the new calculated values. Automatic calibration must also be verified.

VI. TLD Preparation

A. Anneal all TLDs for calibration within 24 hours prior to irradiation.

B. Irradiate the following TLDs to the specified values for automatic and verification calibration.

Automatic Calibration	Desired Dose
15 UD-815	3000 mrem
15 UD-815	500 mrem

Verification Calibration	Desired Dose
10 UD-801	3000 mrem
10 UD-801	2000 mrem
10 UD-801	1000 mrem
10 UD-801	500 mrem
10 UD-801	250 mrem

C. Irradiate the above TLDs in accordance with DSOP 8, Radiation Field Measurements and Calibration Irradiations.

VII. Cleaning of the Optical Block

If the optical block has not been cleaned within the past six months cleaning should be performed in accordance with DSOP 4, Reading TLDs.

VIII. Verification of Current TLD Reader Calibration Parameters

A. Reading of calibration check badges.

1) Load calibration check badges irradiated to values above and below the counter crossover point and a calibration check background badge into a magazine (refer to DSOP 2).

2) Load the magazine directly into the reader.

3) With the reader in BADGE SERVICE MODE, depress the start push button on the automatic reader. Badges will be read automatically and data transferred to the printer.

B. Record the results on DSOP Form 2, Irradiation Verification. Calculate the difference in response between Element 2 and Element 3 to the irradiated dose.

C. If the difference is greater than 25 percent for Element 2 or Element 3, an evaluation shall be made to determine whether any correction should be applied to readings since the last satisfactory check. Notify the Corporate Radiation Safety Officer, if the check fails.

D. If all the differences are within $\pm$ 15 percent for Element 2 and Element 3, proceed with Section IX. If not, then proceed directly with Section X.

IX. <u>Validity Verification of Current Calibration Parameters</u>

A. Irradiations for Verification Calibration

1) Irradiate verification badges (see Section VI. B) in accordance with DSOP 8, Radiation Field Measurements and Calibration Irradiations.

2) Wait at least 24 hours before reading the irradiated badges.

B. Calibration Verification Readout

1) Select BADGE SERVICE MODE on the reader.

2) Load the irradiated dosimeters into a magazine, and insert it into the reader.

3) Depress the START push button on the reader to read the dosimeters.

4) Calculate the average, standard deviation, percent standard deviation, and the percent difference of average reading from exposure for each element at each exposure level. Record all data on DSOP Form 9, Panasonic UD-710A Automatic TLD Reader Calibration Record and attach the printer printout.

C. Compare the verification results to the limits for acceptance presented in Section XI C5. If the limits are met, proceed with approval of calibration; if the limits are not met proceed with Section X, Automatic Calibration Procedure.

D. The CRSO may authorize adjustment of the frequency counter conversion coefficient or photon counter conversion coefficient, based on the data available above.

X. Automatic Calibration Procedure

A. This procedure is for use of the UD-815A TLD for-calibration. Any other type of TLD will not work for automatic calibration.

B. Verify that the computer and printer are set up to receive data from the Panasonic UD-710A Reader.

C. Depress PARAM key until PARAMETER is displayed, and ENTER 2 for a parameter dump and a listing of the reader parameters will be printed.

D. Retain this listing of parameters with the calibration documentation.

E. Determine the reader sensitivity correction factor.

1) Select BADGE SERVICE MODE and load an empty magazine into the reader.
2) Depress START push button, and ten reference light measurements are performed. Depress STOP before the reference light measurements are finished.
3) Depress DATA key until COR FACTOR is displayed.
4) If COR FACTOR is less than .950, then cleaning of the optical block should be done.

5) If after repeated cleaning the correction factor remains less than .950, notify qualified service personnel to determine the cause and take corrective action.

6) Record correction factor on DSOP Form 9.

F. Determine the conversion coefficient for the frequency counter.

1) Select READER CHECK mode.

2) Depress MODE key until RS-232C is displayed.

3) Check MODE, make sure it is set at 1 and BAUD RATE to 2.

4) Verify that the computer and printer are set up properly to accept data from the reader.

5) Select BADGE TEST mode and enter date, irradiation dose for the frequency counter range (above the crossover point), and C for CAL. Depress the ENTER key.

6) Load at least ten UD-815 badges that have been irradiated to 3000 mR into a magazine for the frequency counter range.

7) Load the magazine into the reader, and depress the START push button.

8) Reader will process all the badges in the magazine, and results will be indicated as pulse counts.

9) Results will be transferred to the printer and computer as badges are processed for Elements 3 and 4.

10) Retain the pulse counts printout for the frequency counter range and attach to DSOP Form 9.

11) The conversion coefficient is automatically_calculated and internal parameters changed for the frequency counter (FC) as follows:

$$FC = \frac{\dot{D}_{FC}}{N_{FC}}$$

$\dot{D}_{FC}$ = irradiated dose for frequency counter range

N_{FC} = average of pulse counts obtained for frequency counter range

12) Record the new conversion coefficient for the frequency counter on DSOP Form 9.

G. Determine the conversion coefficient for the photon counter.

1) Depress RETRN and enter the irradiation dose for the photon counter range (below the crossover point) and C for CAL.

2) Load at least 10 UD-815 badges that have been irradiated to 500 mR into a magazine for the photon counter range.

3) Repeat steps F7, F8, and F9 above.

4) Retain the pulse counts printout for the photon counter range and attach to DSOP Form 9.

5) The conversion coefficient is automatically calculated and internal parameters changed for the photon counter (PC) as follows:

$$PC = \frac{D_{PC}}{N_{PC}}$$

D_{PC} = irradiated dose for photon counter range

N_{PC} = average of pulse counts obtained for photon counter range.

H. List parameters after calibration.

1) Verify that the computer and printer are set up to receive data from the reader.

2) Depress PARAM key until PARAMETER is displayed, and ENTER 2 for a parameter dump and a listing of the reader parameters will be printed.

3) Retain this listing of the parameters with the calibration documentation.

XI. Verification of Calibration

A. Initial Settings

1) Select READER CHECK mode.

2) Depress MODE key until PROCESS MODE is displayed, and change READER COR to 1.

B. Irradiations for Verification Calibration

1) Irradiate verification badges to doses listed in Section VI. B (Verification Calibration) in accordance with DSOP 8, Radiation Field Measurements and Calibration Irradiations.
2) Wait at least 24 hours before reading badges.

C. Calibration Verification Readout

1) Select BADGE SERVICE mode on the reader.
2) Load the irradiated dosimeters into a magazine and insert it into the reader.
3) Depress the START push button on the reader to read the dosimeters.
4) Calculate the average, standard deviation, percent standard deviation, and the percent difference of average reading from exposure for each element at each exposure level and record on DSOP Form 9.
5) The reader calibration is acceptable if the following criteria are met during calibration verification:

    a) The average reading for each element is ± 10 percent of the irradiated value.
    b) The percent standard deviation for each element is ± 10 percent of the average reading.

6) If verification badges are not within limits, contact the Corporate Radiation Safety Officer (CRSO).

7) The CRSO may authorize adjustment of the frequency counter conversion coefficient or photon counter conversion coefficient.

XII. Approval of Calibration

A. Upon completion of the calibration, submit DSOP Form 2 and DSOP Form 9 to the Corporate Radiation Safety Officer for approval.

B. A calibration sticker of the appropriate type shall be placed on the reader after approval.

XIII. Records

Retain all calibration results in the dosimetry files for a period of thirty years.

BURROUGHS WELLCOME CO.
Radiation Protection Department

PANASONIC UD-710A AUTOMATIC TLD READER

CALIBRATION RECORD

Date of Calibration: ______________________ Type: Personnel

Date of Last Calibration: ______________________ Type: Personnel

Reason for Calibration (check one)

Routine ____________________ Calibration Check Failure ____________________

After Reader Maintenance ________________ Other ________________ Explain:

____

____

Irradiation for Calibration					Source			
Dose (mR)	Irradiation Date	Distance (cm)	Time (min.) Calculated	Source S.N.	Cs-137 Activity (Ci)	Strength mR/min	Date Measured	Instrument Model/S.N.

Were any problems encountered during optical block cleaning? Yes ___ No ___

If Yes, Explain ____

Reader Calibration

Photon Counter Conversion Coefficient — ____________ E-5 mR/cts

Frequency Counter — ____________ E-3 mR/cts

Reference Light Standard ______E______ cts

Initial Reader Correction Factor Prior to Calibration ___________ (must be ≥0.950)

Calibration Method (check one)

___ 1. Verification of current parameters

___ 2. Automatic

Calibration of the Frequency Counter

New Conversion Coefficient of Frequency Counter ____________ E-3 mR/cts

BURROUGHS WELLCOME CO.
Radiation Protection Department

PANASONIC UD-710A AUTOMATIC TLD READER

CALIBRATION OF THE PHOTON COUNTER

New Conversion Coefficient of Photon Counter ____________ E-5 mr/cts

New Reference Light Standard ____________ E cts

Verification of Calibration

Irr Dose ____ mR	Element 1	Element 2	Element 3	Element 4
Avg. Reading (R)	________	________	________	________
Std. Dev.	________	________	________	________
% Std. Dev.	________ %	________ %	________ %	________ %
($\overline{R}$ – I)/I *100	________ %	________ %	________ %	________ %

Irr Dose ____ mR	Element 1	Element 2	Element 3	Element 4
Avg. Reading (R)	________	________	________	________
Std. Dev.	________	________	________	________
% Std. Dev.	________ %	________ %	________ %	________ %
($\overline{R}$ – I)/I *100	________ %	________ %	________ %	________ %

Irr Dose ____ mR	Element 1	Element 2	Element 3	Element 4
Avg. Reading (R)	________	________	________	________
Std. Dev.	________	________	________	________
% Std. Dev.	________ %	________ %	________ %	________ %
($\overline{R}$ – I)/I *100	________ %	________ %	________ %	________ %

Irr Dose ____ mR	Element 1	Element 2	Element 3	Element 4
Avg. Reading (R)	________	________	________	________
Std. Dev.	________	________	________	________
% Std. Dev.	________ %	________ %	________ %	________ %
($\overline{R}$ – I)/I *100	________ %	________ %	________ %	________ %

Irr Dose ____ mR	Element 1	Element 2	Element 3	Element 4
Avg. Reading (R)	________	________	________	________
Std. Dev.	________	________	________	________
% Std. Dev.	________ %	________ %	________ %	________ %
($\overline{R}$ – I)/I *100	________ %	________ %	________ %	________ %

Performed By ______________________________ Date ______________

Approved By ______________________________ Date ______________
CRSO

CALIBRATION STICKER

PANASONIC UD-710A AUTOMATIC
TLD READER CALIBRATION

Date of Calibration ______________________________

Photon Conversion Coefficient ____________________ E-5 mR/cts

Frequency Conversion Coefficient __________________ E-3 mR/cts

Reference Light Standard _________________________

Date Next Calibration Due ________________________

Performed By: ____________________ Date: __________

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

MEASUREMENT OF STANDARD RADIATION FIELD AND CALIBRATION IRRADIATIONS

DSOP 8

I. Purpose

A. This instruction provides a method for using a condenser R-meter and chamber to measure exposure rates with high accuracy and traceability to the National Bureau of Standards.

B. This instruction also provides a standard method of irradiating TLDs for calibration and other quality control purposes.

II. Responsibilities

A. This procedure covers the measurement of a standard radiation field with a condenser R-meter.

B. This procedure covers the irradiation of TLDs for calibration or quality control checks.

C. This procedure applies to the Staff Specialist in charge of personnel dosimetry.

III. Measurement of a Standard Radiation Field

A. Summary of Method

The chamber that will be used in the calibration is charged and placed in a radiation field. The time it remains there is checked by a timing device. At the completion of the test, the chamber is removed and positioned in the reader. The exposure is read and divided by the exposure time to determine the exposure rate. To correct the energy response due to temperature, and pressure, graphs and data supplied by Victoreen are used. By applying these corrections, the "true" exposure rate is found.

B. Equipment and Materials

Victoreen Model 570 Condenser R-meter

J.L. Shepherd 28-5D Calibrator

Thermometer

Barometer

C. Precautions When Using the Condenser R-meter

1. The R-meter will not give correct readings if any dust, lint, or other foreign material is inside the reader contacts or the chamber contacts.

2. The chambers are not designed for rough handling, be very careful when using them.

3. Before using the R-meter, ascertain probable exposure rates with a survey meter.

4. The chamber cap must be on when using the chamber.

D. Procedure for Use of Condenser R-meter

1. The R-meter must be inspected prior to use.

   a) Visually inspect the contact of the chamber(s) to be used. If any foreign material is found, remove it with forceps, cotton swabs, or other means.

   b) Visually inspect contact area of reader for foreign material. If any foreign material is found, remove it with forceps, cotton swabs, or other means.

c) Inspect the chamber for signs of deterioration or damage. Do not use a suspected damaged chamber.

d) Plug in the reader and turn the "zero set" wheel to the "ON" position. Check the fuse light to be sure it is on, if not, check the fuse and replace if necessary.

e) Check to be sure the scale inside the reader is illuminated. If not, replace the bulb.

f) Turn the "Charge-Discharge" wheel to the "Charge" position. Hold it in this position while moving the "zero set" wheel until the hairline is on zero.

g) Release "Charge-Discharge" wheel, the hairline should remain at zero. If it drifts off scale, there is probably some foreign material on the contact area. Reinspect the area as in a and b above.

h) Select the chamber to be used and insert the chamber into the reader by aligning the pin on the chamber with the pin on the reader. Insert the chamber and turn one quarter turn to the right or left. The chamber is now secured.

i) Leakage check.

1. Zero the chamber. Turn the "Charge-Discharge" wheel to the "Charge" position. Hold it in this position while moving the "zero set" wheel until the hairline is on zero.

2. Remove the chamber only enough to make the alignment pin visible. Rotate the chamber so that it will not insert into the reader.

3. Discharge the reader by operating the "Charge-Discharge" wheel to the "Discharge" position.

4. Reinsert the chamber as in h above.

5. The hairline should move to a point corresponding to the chamber

<u>Chamber</u>	<u>Reference Point</u>
.025 R	.018 + .020

2. Using the Condenser R-meter

a) Insert the chamber into the reader and zero as in D1f and D1g above and replace the chamber cap. Do not reset the reader to zero if the hairline moves when the reader contacts are broken. Do not use the reader again until the same chamber is read out.

b) Position the chamber at the predetermined distance.

c) Obtain barometric pressure and temperature. Record these values on DSOP Form 13.

d) Start the timer and expose the chamber long enough to get a dose of at least 20% of full scale. Enter the time on DSOP Form 13.

e) At the end of the exposure period, remove the chamber from the exposure area.

f) Insert the chamber into the reader. The hairline will move to a location on the scale. Record the reading on DSOP Form 13.

g) Charge the chamber and check to ensure that the chamber is rezeroed.

E. Calculations for the Condenser R-meter

1. Correct the reading for energy response.

   a) For Cs-137, the energy correction factor is obtained from the latest Victoreen Response Test Data sheet for the specific chamber.

   b) For other energies, the energy correction factor must be obtained from the energy response graphs for the specific type of chamber. Locate the energy on the horizontal axis of the graph and follow the point on the curve over to the vertical axis where you will find the indicated/true ratio. The inverse of this ratio is the energy correction factor. Enter the energy correction factor on DSOP Form 13.

2. Correct for air density. Obtain the temperature and pressure and relate them to the Air Density Correction Table, Table 4. Find the correction factor and enter it on DSOP Form 13.

3. Determine the exposure rate. Using the energy and air density correction factors, determine the exposure rate, X in mR/min, using the following formula and record it on DSOP Form 13.

$$X = \frac{R * d * E}{T}$$

R = R-meter reading in roentgen

d = Air density correction factor

E = Energy correction factor

T = Exposure time in minutes.

F. Results for the Condenser R-meter

1. Log the results on DSOP Form 13. This will be filed in the Radiation Protection Department.

2. In addition to the completion of DSOP Form 13, the exposure rates at various distances from the calibrator are plotted on semilog paper for each source/shield configuration.

3. A minimum of three points are required for each graph.

4. The original graphs shall be filed with DSOP Form 13 and a copy of the current graph shall be posted in the calibration facility.

IV. Calibration Irradiations

A. Summary

The TLDs are irradiated in standard personnel badge holders using a J. L. Shepherd Calibrator (120 mCi Cs-137 source). Personnel badges are clipped to the back side of the tray with a polyethylene phantom directly behind the badge. Badges are irradiated for a predetermined amount of time which corresponds to the dose desired.

B. Precautions

1. A TLD must be worn at all times inside the irradiation facility, regardless of source position.

2. Access to the facility should be locked and posted as a "High Radiation Area" at all times.

C. Leak Testing

1. Leak testing of the irradiator source will be performed every six months.

2. Wipes shall be taken from the nearest accessible surface with the source in the "OFF" position. This surface should be at the top of the irradiator where the control rod extends through the well.

D. Operation

1. Pre-irradiation

a. Before entering the irradiation room, verify the source is in the "down"" position with a survey instrument and ensure that all persons present are wearing appropriate personnel dosimetry.

b. Set up equipment to be irradiated. Select a point between 40 cm and 60 cm from the Cs-137 source. Measure the radiation exposure as specified in this instruction. For personnel badges, clip the badge to the back part of the tray. Place a calibration phantom behind all badges to be irradiated.

c. Post signs on the facility entrance door with the following:

"High Radiation Area"

"Irradiator in Use Do Not Enter"

d. Make a final check to assure no person is in the irradiation room.

2. Irradiation

a. Plug the J.L. Shepherd Model 28-5D Irradiator's electrical cord into a wall socket.

b. Determine the length of time that the badges are to be exposed.

c. To expose the source, pull the control rod up. The indicator lights on the control panel will change to red meaning the source is exposed.

d. The operator should remain behind the irradiator at all times while the control rod is up.

e. Irradiate the TLDs for a length of time equal to the desired exposure divided by the exposure rate.

f. The exposed source should be turned off at the predetermined time by pushing the control rod down.

g. After completion of any exposure reset the timer.

h. Document the irradiation data on the DSOP Form 13.

i. Unplug the irradiator at the end of use.

EXPOSURE RATE DETERMINATION BY CONDENSER R-METER

Chamber Serial #	Distance (cm)	Time (hrs.)	(mm of Hg) Pressure	(°F) Temp.	Air Density Correct Factor	Energy (KeV)	Energy Correction	Reading (R)	Exposure Rate $(\frac{mR}{min})$

Performed By: ______________________ ____________ DATE

Approved: ______________________ CRSO ____________ DATE

DSOP Form 13

BURROUGHS WELLCOME CO.
Radiation Protection Department

AIR DENSITY CORRECTION TABLE

Table 4

This instrument is calibrated in International Roentgens corrected to 0°C when used at 22°C and 760 mm mercury (Hg) barometric pressure. For temperatures other than 22°C and pressures other than 760 mm hg, multiply the scale reading by the factor obtained from the following table.

Inches	Mm.	F.60.8 C.16	64.4 18	68.0 20	71.6 22	75.2 24	78.8 26	82.4 28	86.0 30	89.6 32	93.2 34	96.8 36	100.4 38	104.0 40
19.68	500	1.489	1.499	1.509	1.520	1.530	1.541	1,551	1.561	1.571	1.582	1.592	1.602	1.613
20.08	510	1.460	1.469	1.479	1.490	1.499	1.510	1.520	1.530	1.540	1.551	1.561	1.571	1.581
20.47	520	1.431	1.441	1.451	1.461	1.471	1.481	1.491	1.500	1.510	1.520	1.530	1.540	1.550
20.87	530	1.405	1.414	1.424	1.434	1.444	1.453	1.463	1.473	1.482	1.492	1.502	1.512	1.521
21.86	540	1.378	1.388	1.397	1.407	1.416	1.426	1.435	1.445	1.454	1.464	1.474	1.483	1.493
21.65	550	1.354	1.363	1.373	1.382	1.391	1.401	1.410	1.419	1.429	1.438	1.448	1.457	1.466
22.05	560	1.329	1.338	1.348	1.357	1.366	1.375	1.384	1.394	1.403	1.412	1.421	1.431	1.439
22.44	570	1.306	1.315	1.324	1.333	1.342	1.351	1.360	1.369	1.378	1.387	1.396	1.405	1.414
22.83	580	1.283	1.292	1.301	1.310	1.319	1.328	1.337	1.345	1.354	1.363	1.372	1.381	1.389
23.23	590	1.262	1.270	1.279	1.288	1.297	1.305	1.314	1.323	1.331	1.340	1.349	1.358	1.366
23.62	600	1.241	1.249	1.258	1.267	1.275	1.284	1.293	1.301	1.309	1.318	1.327	1.336	1.344
24.02	610	1.220	1.229	1.237	1.246	1.254	1.263	1.271	1.279	1.288	1.297	1.305	1.314	1.322
24.41	620	1.200	1.208	1.217	1.225	1.233	1.242	1.249	1.258	1.266	1.275	1.283	1.292	1.299
24.80	630	1.181	1.189	1.198	1.206	1.214	1.222	1.230	1.239	1.247	1.255	1.263	1.271	1.279
25.20	640	1.164	1.171	1.180	1.188	1.196	1.204	1.212	1.220	1.228	1.236	1.244	1.252	1.260
25.59	650	1.145	1.153	1.161	1.169	1.177	1.185	1.193	1.201	1.208	1.216	1.224	1.232	1.240
25.98	660	1.127	1.135	1.143	1.151	1.589	1.167	1.174	1.182	1.189	1.198	1.206	1.213	1.221
26.38	670	1.111	1.119	1.126	1.134	1.142	1.149	1.157	1.165	1.172	1.180	1.188	1.195	1.203
26.77	680	1.095	1.103	1.110	1.118	1.125	1.133	1.141	1.148	1.156	1.163	1.171	1.179	1.186
27.16	690	1.078	1.086	1.093	1.101	1.108	1.116	1.123	1.131	1.138	1.146	1.153	1.161	1.168
27.56	700	1.064	1.071	1.079	1.086	1.093	1.101	1.108	1.115	1.123	1.130	1.137	1.145	1.152
27.95	710	1.048	1.055	1.063	1.070	1.077	1.084	1.092	1.098	1.106	1.113	1.121	1.128	1.135
28.35	720	1.033	1.041	1.048	1.055	1.062	1.069	1.076	1.083	1.091	1.098	1.105	1.112	1.119
28.54	725	1.027	1.034	1.041	1.048	1.055	1.062	1.069	1.076	1.083	1.091	1.098	1.105	1.112
28.74	730	1.019	1.027	1.034	1.041	1.048	1.055	1.062	1.069	1.076	1.083	1.090	1.097	1.105
28.94	735	1.013	1.019	1.027	1.034	1.041	1.048	1.055	1.062	1.069	1.076	1.083	1.090	1.097
29.13	740	1.006	1.013	1.020	1.027	1.034	1.041	1.048	1.055	1.062	1.069	1.075	1.083	1.089
29.33	745	.999	1.006	1.013	1.020	1.027	1.034	1.040	1.048	1.054	1.061	1.068	1.075	1.082
29.53	750	.992	.999	1.006	1.013	1.020	1.027	1.033	1.040	1.047	1.054	1.061	1.068	1.075
29.72	755	.986	.993	1.000	1.007	1.014	1.021	1.027	1.034	1.041	1.048	1.065	1.062	1.068
29.92	760	.980	.986	.993	1.000	1.007	1.014	1.020	1.027	1.034	1.041	1.047	1.054	1.061
30.12	765	.972	.979	.986	.993	.999	1.006	1.013	1.020	1.026	1.033	1.040	1.047	1.054
30.31	770	.967	.973	.980	.987	.994	1.000	1.007	1.104	1.020	1.027	1.034	1.041	1.047
30.51	775	.961	.968	.974	.981	.987	.994	1.001	1.007	1.014	1.021	1.027	1.034	1.041
30.71	780	.954	.961	.967	.974	.980	.987	.994	1.000	1.007	1.014	1.020	1.027	1.033
30.90	785	.948	.955	.961	.968	.974	.981	.988	.994	1.001	1.007	1.014	1.021	1.027
31.10	790	.942	.949	.955	.962	.968	.975	.981	.988	.994	1.001	1.008	1.014	1.021

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

PERSONNEL EXPOSURE INVESTIGATIONS

DSOP 9

I. Purpose

This procedure establishes acceptable methods for conducting and documenting personnel exposure investigations.

II. Responsibilities

A. This procedure covers investigations of a variety of situations in which the usual personnel monitoring device readings are unavailable or unreliable as a result of loss, damage, interference, or misuse (intentional or accidental). In these situations, doses are assigned and documented based on the investigations.

B. This procedure also covers investigations of incidents in which personnel exposure in excess of Burroughs Wellcome Co. exposure limits may have occurred.

C. This procedure applies to the Corporate Radiation Safety Officer and Staff Specialist in charge of dosimetry services.

III. Procedure

A. Investigation of Lost or Damaged TLDs or Questionable Results

1. Whenever TLD results are unavailable (lost or damaged) or unreliable for any reason, perform an investigation and document the results including the dose assigned.

2. Determine the individual's dose for the affected exposure period based on the following:

a. Obtain the monthly average dose of each employee working in the same laboratory as the affected individual for the past twelve month period. Average these for the total number of employees with accurate readings in that laboratory.

b. Obtain the monthly average dose for the affected individual for the past twelve month period.

c. Assign the highest average dose obtained as described in Section IIIA2a and Section IIIA2b above as the dose to the affected individual.

3. Document the results of the investigation and the final dose assigned, if any, on the Personnel Exposure Investigation, DSOP Form 12.

4. Upon completion of the Personnel Exposure Investigation, obtain the signature of the involved individual.

5. Submit the Personnel Exposure Investigation Form, DSOP Form 12 to the Corporate Radiation Safety Officer for review and approval.

6. Place a copy in the individual's exposure history file.

7. Update the computer listing of doses by using the TLDADD procedure (See Appendix A).

B. Investigating Possible Exposures in Excess of Company Limits.

1. Whenever it appears that an individual's dose may have exceeded a Company limit, the Staff Specialist, who determines the dose, must advise the Corporate Radiation Safety Officer as soon as possible.

2. The CRSO shall be responsible for conducting the investigation and compiling all facts pertinent to the event. The CRSO should consider using the following investigative methods as appropriate to the situation.

   a. Interviews: These should be conducted as soon as possible, documented, and signed by all interviewers and the interviewee.

   b. Compilation and review of pertinent documents: dosimetry records (past and present), procedures, radioisotopes ordered and used.

   c. Conduct special tests pertinent to the specific case, such as: quality control tests of dosimetry and survey instrumentation, special calibrations.

3. If it is determined that the individual did receive a dose in excess of company limits, a report is submitted to the Isotope Committee within thirty days. The Isotope Committee must meet and rectify the cause of the excess dose.

4. If the badge reading is not reliable then Section IIIA is followed to assign a dose.

5. A copy of the final incident report shall be placed in the individual's exposure history file regardless of whether it is determined that an overexposure actually occurred or not.

C. Resolving Contested TLD Data

1. If TLD data or test reports are contested by an individual or an organization, the Corporate Radiation Safety Officer (CRSO) shall be notified.

2. The CRSO shall decide what actions may be necessary to resolve the contention. Action could include special tests or evaluations of dosimetry equipment, special audits of dosimetry records or investigations of personnel exposures.

3. The CRSO shall make the final judgement and document the contention and all related facts and the resolution of the contention. He or she shall inform the appropriate management levels, as necessary, dependent upon the nature of the contention.

4. The documentation shall include a report addressing the contention to be furnished to the individual or organization contesting the data.

BURROUGHS WELLCOME CO.
Radiation Protection Department

PERSONNEL EXPOSURE INVESTIGATION

I. PERSONNEL DATA

Name ______________________________ SSN ______________
LAST FIRST MI

Birth Date __/__/__ (Yr Mo Da) Employer ______________ Exp. Period __/__/__ (Yr Mo Da) to __/__/__ (Yr Mo Da)

II. DESCRIPTION OF OCCURRENCE

Device: TLD ☐ Reason: Lost ☐ Damaged ☐ High or Abnormal Reading ☐

TLD Identification No. ______________ Date/Time of Occurrence ______/______

Work Being Done: ______________________________

Remarks: ______________________________

III. OTHER PERSONNEL (for others working in same area for past 12 month period, dose in mrems)

	Month	1	2	3	4	5	6	7	8	9	10	11	12	Avg	Average Workers Dose
1.															
2.															
3.															
4.															
5.															
6.															

IV. PREVIOUS ASSIGNED DOSIMETRY RESULTS FOR AFFECTED INDIVIDUAL (past 12 month period, dose in mrems)

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
Avg

V. SPECIAL TESTS PERFORMED

TLD Pulled for QC Test: Pass ☐ Fail ☐

VI. FINAL ACTION

☐ No Dose Assignment, Normal TLD Readings Accepted
☐ Dose Assigned Based on This Investigation and Entered

Whole Body __________ MREM

Skin __________ MREM

Basis: TLD ☐ Co-workers ☐ Other ☐

Discussion: ______________________________

____

If New TLD Badge Assigned, No. __________

Individual's Signature: ______________________ Date: __________

Investigated By: ______________________ Date: __________

Reviewed By: ______________________ Date: __________

DSOP Form 12 CRSO

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

TLD READER INTERCOMPARISON AND PERFORMANCE TESTING

DSOP 10

I. Purpose

This procedure establishes standard methods for performance testing and evaluation of Burroughs Wellcome Co.'s Panasonic TLD reader.

II. Responsibilities

A. This procedure addresses monthly cross-checks of the Panasonic TLD Reader in service, semi-annual intercomparison with a non-Burroughs Wellcome testing facility, and performance testing for accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP).

B. This procedure applies to the Corporate Radiation Safety Officer and the Staff Specialist of the Radiation Protection Department.

III. Materials and Equipment

Panasonic UD-801 TLDs

Panasonic UD-710A Automatic TLD Reader

Texas Instrument Silent 700 Printer

J. L. Shepherd Model 28-5D Calibrator

IV. Prerequisites

Personnel performing the irradiation of badges shall be qualified to operate the J. L. Shepherd Model 28-5D Calibrator in accordance with DSOP 8, Radiation Field Measurements and Calibration Irradiations.

V. Summary of Method

For monthly cross-checks, TLDs are irradiated by the Corporate Radiation Safety Officer (CRSO) to known values in selected exposure ranges and given to the Staff Specialist for processing. The Staff Specialist reads the badges and returns the results to the CRSO. The results are compared to the known values.

For semi-annual intercomparison, the TLDs are annealed by the Staff Specialist and sent to a testing laboratory for irradiation in unknown radiation categories. The intercomparison badges are to be processed by the Staff Specialist. The results are analyzed and reported to the testing laboratory. The performance of Burroughs Wellcome Co. is characterized by the testing laboratory and reported to the Company.

For the accreditation performance test, TLDs are annealed by the Staff Specialist and sent to the NVLAP testing laboratory for irradiation in two different categories. The irradiated badges are processed by the Staff Specialist. The results are analyzed and reported to the testing laboratory. The performance of Burroughs Wellcome will be characterized by the testing laboratory according to the criteria specified in ANSI N13.11-1983 and reported to Burroughs Wellcome Co.

VI. Frequency

A. The monthly cross-checks shall be performed at intervals not exceeding 45 days.

B. The semi-annual intercomparison shall be started during the first and sixth month of each year.

C. The NVLAP performance testing is conducted at least every two years.

VII. <u>Procedure for Monthly Cross-Check</u>

A. Select and anneal six personnel TLDs for irradiation and three TLDs for controls. Load the TLDs in personnel badge holders.

B. Using the J. L. Shepherd Calibrator and in accordance with DSOP 8, the CRSO will irradiate each TLD to a different dose value in the range from 20 mrem to 5 rem. Do not irradiate the controls.

C. Record the date, TLD identification numbers, delivered dose (D), and name of person performing irradiation on DSOP Form 10, TLD Reader Cross-Check Report.

D. Label each badge with the words "cross-check" or "cross-check control," depending on if they have been irradiated or if they are controls.

E. Send the irradiated TLDs and control badges along with Form DSOP 11 to the Staff Specialist.

F. The badges are processed and the results returned to the Corporate Radiation Safety Officer (CRSO).

G. The CRSO should evaluate the results by performing the calculations on DSOP Form 10.

H. Attach all annealing printouts, and reading printouts to DSOP Form 10.

I. After review by the CRSO and following any corrective action which is necessary, foward a copy of DSOP Form 10 to the Staff Specialist (See Section XA for limits and corrective action).

VIII. Procedure for Semi-Annual Intercomparison

A. Select and anneal 23 valid, undamaged personnel TLDs.

B. Label 20 TLDs as "INTERCOMPARISON #X" where X is a number from 1 to 20. Mark 21, 22, 23 as "Control."

C. Load the TLDs in personnel badge holders.

D. Prepare a letter listing the TLDs by label identification and mail with the TLDs to the testing facility.

E. The TLDs are irradiated at the testing laboratory and returned to Burroughs Wellcome Co. for processing.

F. Obtain a parameter dump from the reader.

G. Process the TLDs in accordance with DSOP 4, Reading TLDs.

H. Evaluate the results of the intercomparison badges by using the algorithm in Appendix B.

I. Submit the intercomparison badges, readout sheets, parameter dump, and dose calculations with dates and signatures to the Corporate Radiation Safety Officer for review. Do not return the intercomparison TLDs to routine service until after the testing laboratory report has been reviewed.

J. The CRSO shall review the results for clerical and technical error prior to submitting the final report to the testing laboratory. Report the results of each irradiated badge to the testing laboratory within 15 days of receipt of the TLDs.

K. Upon receipt from the testing laboratory, the CRSO shall review the performance evaluation report for computational and clerical errors on the part of the testing laboratory. Also, results are evaluated with respect to limits in Section X.

IX. Procedure for National Voluntary Laboratory Accreditation Program Performance Testing

A. Select and anneal 38 valid, undamaged personnel TLDs. This is the correct number for application in two radiation categories.

B. Label each TLD as "NVLAP #X" where X is a number from 1 to 30. Mark 31, 32, 33, 34, 35, 36 as "EXTRA and 37, 38 as "Control."

C. Load the 38 annealed TLDs in personnel badge holders.

D. Prepare a letter listing the TLDs shipped by label identification and mail with the TLDs to the testing laboratory.

E. The TLDs are irradiated at the testing laboratory and returned to Burroughs Wellcome Co. for processing.

F. Obtain a parameter dump from the reader.

G. Process the TLDs in accordance with DSOP 4, Reading TLDs.

H. Evaluate the results of the NVLAP badges by using the algorithm in Appendix B.

I. Submit the NVLAP badges, readout sheets, parameter dump, and dose calculations with dates and signatures to the CRSO for review. Do not return the NVLAP badges to routine service until after the testing laboratory report has been reviewed.

J. The CRSO shall review the results for clerical and technical errors prior to submitting the report to the testing laboratory. Report the results of each irradiated badge to the testing laboratory within 15 days of receipt of the TLDs.

K. Upon receipt from the testing laboratory the CRSO shall review the performance evaluation report for clerical errors on the part of the testing laboratory and evaluate the performance results with respect to the limits in Section X.

X. Limits and Corrective Actions

A. For monthly cross-checks, the results are considered acceptable if the following criterion is met:

$$|B| + S \leq 0.5$$

Bias (B), Bias Standard Deviation (S)

See DSOP Form 10 for calculation of Bias and Standard Deviation.

B. For the semi-annual intercomparison, each test category is considered acceptable if the following criterion is met:

$$|B| + S \leq 0.5$$

Bias (B), Bias Standard Deviation (S)

See DSOP Form 10 for calculation of Bias and Standard Deviation.

C. For the NVLAP performance testing, the test categories are reported as passed or failed according to ANSI N13.11-1983.

D. If any of the above criteria are not met, the CRSO shall investigate the reason for failure. Possible areas of concern are:

1. Dirt in reader
2. Sensitivity of TLDs
3. Reader calibration
4. Damaged TLDs
5. Dose algorithm
6. External radiation
7. Malfunction of reader
8. Clerical errors
9. Environmental factors (temperature, humidity).

XI. <u>Records</u>

The following documents will be maintained in the Radiation Protection Department for 30 years for all tests.

* parameter dumps
* annealing and reading printouts
* dose calculations
* TLD Reader Cross-check Report
* TLD Reader Cross-check Results

BURROUGHS WELLCOME CO.
Radiation Protection Department

TLD READER CROSS-CHECK REPORT

Irradiation Date: ____________________ Return Date: ____________________

Badge No.	Delivered Dose (mrem) (D)	Reported Dose (mrem) (R)	Performance Quotient (P)

Equations:

$$Pi = \frac{R-D}{D}$$

$$B = (1/N) \sum_{i=1}^{n} Pi$$

$$S = \frac{\sum_{i=1}^{n} ((Pi - B)^2)^{1/2}}{n - 1}$$

Bias (B) __________

Standard Deviation (s) __________

$|B| + S$ __________

Limit: $|B| + S < 0.5$

Pass/Fail __________

Recommendations: ______________________________

Performed By ______________________________ Date __________

Reviewed By ______________________________ Date __________
CRSO

DSOP Form 10

BURROUGHS WELLCOME CO.
Radiation Protection Department

TLD READER CROSS-CHECK RESULTS

Performed By ______________________________ Date ________________

1. Read the folowing badges in accordance with DSOP4. Do not use the automatic background subtraction on the TLD reader.

2. Return the badges with signed and dated TLD reader printouts to the CRSO.

Control Badge No.

1. ____________________
2. ____________________
3. ____________________

Cross-Check Badge No.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

PERSONNEL QUALIFICATION FOR DOSIMETRY SERVICES

DSOP 11

I. Purpose

This procedure established the qualification requirements for personnel to independently perform dosimetry procedures.

II. Responsibilities

A. This instruction applies to all persons who intend to perform dosimetry procedures without direct supervision by the Corporate Radiation Safety Officer (CRSO).

B. The CRSO is responsible for administering training, certifying the completion of all qualification requirements, and retention of all qualification documents.

III. Qualification

A. An individual must be qualified and certified in order to perform work covered by certain dosimetry procedures without direct supervision of the CRSO.

B. Qualification involves satisfactorily completing the specified prerequisites, direct training with the CRSO, and performance of items listed on the applicable qualification record. Qualification requirements may be waived by the CRSO for individuals who have received special training or experience applicable to specific procedures.

C. After satisfying all qualification requirements, the CRSO shall sign the certification section of the qualification record to authorize the individual to perform that procedure independently.

IV. Requalification

In order to maintain authorization to perform dosimetry procedures, an individual must requalify annually or at intervals not to exceed 15 months.

V. Retraining

A. Whenever a procedure is revised, all qualified personnel shall be retrained on those aspects of the procedure which have changed.

B. Retraining shall be performed prior to first use of the revised procedure by an individual.

C. Retraining shall be documented and a record placed in each individual's training file.

VII. Records

All training qualification records and retraining documentation shall be retained for at least thirty years.

BURROUGHS WELLCOME CO.
Radiation Protection Department

DOSIMETRY QUALIFICATION RECORD

Name: ______________________ SSN: ______________

Procedure Name: TLD Shipment, Acceptance, Verification, and Storage-DSOP 1.

Initial Qualification: ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
None		
II. Direct Training		
A. Procedure DSOP 1	______________	
III. Performance		
A. Accept, verify and store TLD shipment	______________	

Name: ______________________ SSN: ______________

Procedure Name: Preparation of TLDs Before Field use — DSOP 2.

Initial Qualification ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
A. Qualified to use calibrator	______________	
A. Qualified to read TLDs	______________	
II. Direct Training		
A. Procedure DSOP 2	______________	
III. Performance		
A. Prepare a full set of badges including personnel, calibration check, background, and control badges. Perform all steps and complete all documentation.	______________	

BURROUGHS WELLCOME CO.
Radiation Protection Department

DOSIMETRY QUALIFICATION RECORD

Name: ______________________ SSN: ______________

Procedure Name: Quality Control Testing of Thermoluminescent Dosimeters — DSOP 3.

Initial Qualification: ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
A. Qualified to use calibrator		
B. Qualified to read TLDs		
II. Direct Training		
A. Procedure DSOP 3	______________	
III. Performance		
A. Perform and document testing of 50 badges	______________	

Name: ______________________ SSN: ______________

Procedure Name: Reading TLDs — DSOP 4.

Initial Qualification ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
None		
II. Direct Training		
A. Theory of TLD system operation	______________	
B. Procedure DSOP 4	______________	
III. Performance		
A. Daily calibration check	______________	
B. Background determination	______________	
C. Personnel badge reading — 50 badges	______________	
D. Cleaning of reader	______________	

BURROUGHS WELLCOME CO.
Radiation Protection Department

DOSIMETRY QUALIFICATION RECORD

Name: ______________________________ SSN: ______________

Procedure Name: Dosimetry Issuance — DSOP 5.

Initial Qualification: ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
None		
II. Direct Training		
A. Procedure DSOP 5	______________	
III. Performance		
A. Issue 5 TLDs	______________	

Name: ______________________________ SSN: ______________

Procedure Name: TLD Exchange — DSOP 6.

Initial Qualification ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
A. None		
II. Direct Training		
A. Procedure DSOP 6	______________	
III. Performance		
A. Perform a complete TLD exchange	______________	

BURROUGHS WELLCOME CO.
Radiation Protection Department

DOSIMETRY QUALIFICATION RECORD

Name: ______________________________ SSN: ________________

Procedure Name: Calibration of Panasonic UD-710A Automatic Reader — DSOP 7.

Initial Qualification: ________________ Requalification: ________________

	Signature	Date
I. Prerequisites		
A. Qualified to use calibrator		
B. Qualified to read TLDs		
II. Direct Training		
A. Procedure DSOP 7	________________	
III. Performance		
A. Perform and document automatic calibration	________________	

Name: ______________________________ SSN: ________________

Procedure Name: Radiation Field Measurements and Calibration Irradiations — DSOP 8.

Initial Qualification ________________ Requalification: ________________

	Signature	Date
I. Prerequisites		
A. Qualified to read TLDs	________________	
II. Direct Training		
A. Procedure DSOP 8	________________	
III. Performance		
A. Operate the condenser R-meter	________________	
B. Irradiate badges to five different doses	________________	

BURROUGHS WELLCOME CO.
Radiation Protection Department

DOSIMETRY QUALIFICATION RECORD

Name: ______________________________ SSN: ______________

Procedure Name: Personnel Exposure Investigation — DSOP 9.

Initial Qualification: ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
None		
II. Direct Training		
A. Procedure DSOP 9	______________	
III. Performance		
A. Perform an investigation concerning abnormal TLD reading	______________	

Name: ______________________________ SSN: ______________

Procedure Name: TLD Reader Intercomparison and Performance Testing — DSOP 10.

Initial Qualification ______________ Requalification: ______________

	Signature	Date
I. Prerequisites		
A. Qualified to use calibrator	______________	
B. Qualified to read TLDs	______________	
II. Direct Training		
A. DSOP 10	______________	
III. Performance		
A. Perform and process one set of TLD reader cross-check badges	______________	

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

APPENDIX A

Computer Support Services for Burroughs Wellcome Co. Personnel Dosimetry Services

By

Mr. David C. Pressel

Burroughs Wellcome Co.

Computer Services Department

THE TLD RADIATION EXPOSURE SYSTEM AT BW

NOTE: Reference to the word "dose" is used to mean "dose equivalent". Badge "exposure" readings are converted to "dose equivalents" by the TLD program, TLD001.

The TLD Radiation Exposure System is an integrated set of programs used to augment the capture of radiation exposure readings on the Panasonic UD-710A Automatic TLD Reader. Records of radiation exposure are maintained for scientific personnel as required by state law. This function is carried out by personnel from the Radiation Protection Department. The program includes the distribution, collection, and recording of exposure measured on individual Thermoluminescent Dosimeters (TLD) from personnel covered in the monitoring program. Personnel whose activity necessitates such exposure monitoring are assigned to one of two reading schedules, monthly or quarterly.

At the end of an exposure period, badges are collected and 'read' on the Panasonic reader. Badges are made of several phosphors, with appropriate shielding, which show radiation exposure in a quantifiable way. 'Reading' a badge on the reader quantifies exposure through heating phosphors which emit luminescence and counting electrons driven off. The final stage of this process is the automatic annealing of the phosphors so they are 'zeroed' for the next period.

The Panasonic Reader is directly connected to BW's System/7 data capture hardware. Radiation Safety personnel log on to the System/7 prior to running a set of badges. At the end of the run, the data file created is automatically closed and spooled to the Radiation Safety user ID on the in-house interactive computer system (CMS at RTP). Once received, the data file can be read into the user's disk area and is ready for further processing.

The purposes of this software system are several:

1) To convert the badge readings into dose equivalent values of MREMS, based on an algorithm specific to the reader and badges used.

2) To update and maintain computerized files of dose history for each employee covered by the program.

3) To generate reports of radiation dose at the end of each scheduled monitoring period, flagging with warnings those above set limits.

4) To generate quarterly reports of personnel radiation dose for filing with Radiation Protection Department Staff (H103 reports).

The exposure system software is installed on the Radiation Protection Department CMS user ID. It consists of one main EXEC procedure named NEWTLD which drives four program modules (TLD001, TLD002, TLD003 and TLD004). There is also a procedure named BLABEL, designed to generate labels for TLD badges, as well as several procedures for file maintenance (TLDMOV, TLDEDIT, TLDADD, TLDCAL).

The four modules which make up the NEWTLD procedure are quite distinct in their function:

TLD001 operates on a file of badge readings, converting them to calculated dose values, kicking out bad readings, and creating a temporary file on new dose readings and a listing of those values.

TLD002 checks the temporary file of dose readings to ensure against duplicate readings.

TLD003 processes the temporary file of dose readings, updating the personnel histories and generating an exposure report.

TLD004 is invoked automatically on runs at quarter-end. It takes the current updated exposure history file and generates from it individual H103 reports.

TLD001 MODULE Description

This program is designed to accept readings from the UD-710A Automatic TLD Reader and convert them to shallow (skin) and deep (penetrating) dose equivalents (mrems), based on the nature of the radiation exposed to.

Since the type and energy level of radiation exposure in a laboratory setting is not generally identifiable, and since the four phosphors in the UD-801 personnel dosimeter react differently in the presence of different types of radiation, a primary purpose of this algorithm is to make an intelligent guess about the nature of the radiation, and then provide appropriate factors to convert readings to dose equivalents.

The details of the algorithm are explained in detail in

> Calibration of Panasonic Model UD-710A Automatic TLD Reader and the UD-801 Personnel Dosimeters, Plato and Hudson, School of Pub. Health, U. Michigan - Ann Arbor 48109 (December 1979).

Basically, each badge read gives four exposures e1-e4. Two ratios are calculated to determine exposure type:

ratio a = e1 / e2

ratio b = e1 / e3

Determination of exposure type allows calculation of shallow dosage by factoring e1 and calculation of deep dosage by factoring e2.

The e4 phosphor is a duplicate of e3. It is not used in the exposure calculation, but may be incorporated as an error estimator at some point in the future.

This algorithm and the factors used are only valid on the UD-710A, using UD-801 personnel dosimeters. It cannot be used with other TLD instruments or badges. Correlation with previous exposure readings on the earlier reader/badges is unknown. No information is recorded on how or if the earlier instrument was validated.

TLD002 MODULE description

This program goes through the temporary file of calculated exposures, which have been sorted in ascending order by badge number. If a duplicate reading is found, an error message is produced and processing stops.

TLD003 MODULE description

This program merges the new exposure data with historical data from the most recent version of TLDHIST. In the process, records with missing values (no reading this period) are flagged for future reference. On any given run the program is updating either all quarterly badges or all monthly badges. (Badge readings from different schedules cannot be updated simultaneously. This design feature is an intentional check and causes the system to terminate with appropriate error messages.)

As exposure histories are updated, a dose equivalent report is generated on the system printer. Flags are provided for dose levels above set limits as follows:

Monthly penetrating: > 200 mrem

Quarterly penetrating: > 625 mrem

Yearly penetrating: > 2500 mrem

Lifetime penetrating: > 5000 mrem * (age - 18) (500 for 18 yr olds)

Monthly shallow: > 2500 mrem

Quarterly shallow: > 7500 mrem

Yearly shallow: > 30000 mrem

TLD004 MODULE Description

When the NEWTLD procedure detects that this is the end of a quarter, it automatically invokes TLD004, which generates H103 reports for all personnel on the schedule being updated (monthly or quarterly). These reports come off the system printer in badge-number order on white paper (two copies). They should be checked to insure completeness before forwarding to regulatory agencies.

PROCESSING EXPOSURE READINGS USING THE NEWTLD PROCEDURE

1) Run badges according to your instructions for the Panasonic reader, using filenames you are accustomed to (TLD1, TLD2, etc.). MAKE SURE THAT MONTHLY AND QUARTERLY BADGES ARE RUN SEPARATELY SO THEY ARE ON DIFFERENT FILES.

2) When the System/7 transmits the data to your CMS id, files show up in the reader as TLD1 SYS7DATA, TLD2 SYS7DATA, etc. These can be

read in using READ * (once for each file). Once accomplished, the files will reside on your A-disk.

3) If you have several files of the same reading schedule (i.e., two files of monthly badge readings for this month) make them into one large file using the COPY command with the APPEND option.

e.g., If TLD1 and TLD2 are monthlies and TLD3, TLD4, TLD5 are quarterlies, make two merged files as follows:

```
COPY TLD2 SYSYDATA A TLD1 = = (APPEND
COPY TLD4 SYSYDATA A TLD3 = = (APPEND
COPY TLD5 SYSYDATA A TLD3 = = (APPEND
```

When finished, TLD1 would contain all monthlies and TLD3 all quarterlies.

4) Invoke the update procedure with NEWTLD or EXEC NEWTLD. The procedure will ask for the name of the data file, as well as the dates for the reporting period. (The end date is the last day of the month or quarter, NOT the first day of the next period.)

5) If the program runs successfully, output will be sent to the main printer upstairs. If it is quarter end, H103 reports are generated automatically. Remember that at quarter end, monthlies and quarterlies are processed separately and two sets of H103's will be produced in badge number order by schedule.

6) DON'T ERASE THE DATA FILES UNTIL YOU HAVE ALL REPORTS IN HAND AND HAVE VERIFIED THEIR CORRECTNESS/COMPLETENESS.

7) If the run fails with error messages, you can correct your problems (hopefully) and rerun the procedure with no ill effects. (Once the run has been made successfully, you won't be able to rerun it.)

POSSIBLE SOURCES OF COMMON ERRORS - WHAT TO DO

- Failure to add new people to file before a run (use TLDADD)

- Duplicate badge reading (most likely the reader failed to catch a hole punched on the badge - check the data file against your records and fix)

- People on the wrong schedule (either a faulty reading of the badge number or a change you failed to catch on the TLDHIST history file - you can use TLDMOV or TLDEDIT to correct the schedule. TLDEDIT is faster but TLDMOV generates an audit trail. You choose.)

- Erroneous warnings on reports (verify birthdate is correct on history file)

- Job ABENDS with ONCODE messages (data problem generally beyond your ability to trace directly - call support personnel. This can also occur with a true program bug but none have surfaced yet.)

ADDING NEW BADGE RECORDS USING THE TLDADD PROCEDURE

1) This procedure is used to add NEW records to the TLD history file. Before a person's badge is read and processed for the first time, a record for that individual must be created on TLDHIST. The procedure is invoked using TLDADD or EXEC TLDADD.

2) Follow the instructions on the screen. Note that badge number, proper reading schedule, and birthdate are absolutely required. Social Security number should be added before quarter end if not available initially.

3) If you have to add more than five records, DUP lines (DUP n to duplicate the top line n times). Do not insert blank lines and type them in; there is more data on this file than you can see.

4) Before filing additions, delete ALL extra lines to the end of the file. FAILURE TO DO THIS WILL REALLY CLOBBER THE CURRENT HISTORY FILE.

Note: If you are restoring a record of an old employee who previously had a badge, DO NOT USE THIS PROCEDURE. Use TLDMOV to get the record back from the dead file. Also be sure that you do not enter new employees twice.

EDITING CURRENT TLD HISTORY WITH TLDEDIT

TLDEDIT is a procedure to fix the textual information associated with a reading history. It is invoked using TLDEDIT or EXEC TLDEDIT.

This procedure generates an editable file where the fields you can change are labeled and in parentheses. When using this procedure, you are using EDGAR, the display editing system, and can use any of the EDGAR commands you want. Changes can be made to the appropriate fields by changing what is in parentheses and FILing the file when finished. (If you use QUIT, of course, no changes will be stored.)

TLDEDIT operates on the most current generation of the TLDHIST DATA file automatically. There is no need for you to have to figure out which one that is to use the procedure.

MOVING AND CHANGING RECORDS WITH TLDMOV

TLDMOV is a procedure which can be used for

- moving TLD records between the current history file and the dead file

- checking status of a badge number to find which file it is on and which reading schedule it is assigned to

- changing the reading schedule for a given badge number

It is invoked using TLDMOV or EXEC TLDMOV. The procedure is menu driven and generally self-explanatory. A log of changes made is sent to the main printer.

Note: DO NOT MOVE RECORDS TO THE DEAD FILE UNTIL YOU HAVE A FINAL H103 ON THE INDIVIDUAL. Once that is done at quarter end, there is no need to clutter the current history files with employees no longer on TLD monitoring schedules, even though they may still be BW employees.

GENERATION OF TLD BADGE LABELS

Labels for TLD badges can be generated automatically using the BLABEL EXEC. This procedure uses data from the current generation of the TLDHIST DATA file to produce a partial or complete set of labels.

To generate labels:

1) Invoke the procedure with the command BLABEL or EXEC BLABEL.
2) The program will ask you if you want a complete set or just a specified range of badge numbers - answer accordingly.

3) When the program is done, labels will be sent to the main printer and can be picked up at the main computer terminal.

Note: If you have two groups of badges needing labels (e.g. 500-505 and 1020-1025) run the procedure twice.

FIELDS DEFINITION TABLE FOR RADIATION EXPOSURE HISTORY FILES

TLD history files are made up of records 198 characters (bytes) long, one for each badge. Records must be in ASCENDING ORDER by BADGE NUMBER.

Files are named TLDHIST DATAxx, where xx is a sequential number, with the largest being most current. Each time an update is run successfully, a new 'generation' of the history file is created. Problem runs will leave old generations intact and not create a new one.

In addition to current history generations, there is also a TLDHIST DEAD FILE with the same record format. Records can be moved to this file using the TLDMOV procedure described elsewhere. The main purpose of this file is to archive records for individuals who have either left the company or are no longer being monitored (reassigned out of the labs). NO RECORD SHOULD BE MOVED TO THE DEAD FILE UNTIL AFTER QUARTER END, THUS MAKING SURE THAT A FINAL H103 REPORT IS GENERATED.

```
0000M  12345ABRAHAMS, SANDERS L 801231 415701442PHARM       0    0 0 0
```

cols	length	field description
1-4	4	Badge number assigned to individual. If badge is three digits long, put a '0' in column 1.
5	1	'M' for monthly schedule, 'Q' for quarterly
6-11	6	Company payroll number if known or ' 00000'
12-40	29	Last-name, first-name initial
4-46	6	Birthdate (absolutely needed) yymmdd format.

```
0000M  12345ABRAHAMS, SANDERS L 801231 415701442PHARM       0    0 0 0
```

cols	length	field description
47-56	10	Social security no., first space usually blank NO HYPHENS are used. If you don't know it yet, use a blank followed by nine '0's. Fix before quarter end.
57-64	8	Reasonable abbreviation of department, padded with blanks on the right. Be consistent for clarity.
65-69	5	Mrems penetrating dose reported for work prior to BW. If there is none, '0' IN COLUMN 69. In all cases use whole numbers an pad with blanks on the left.
70-74	5	Mrems dose for BW months prior to current year. This field is updated automatically by the program. For new records put a '0' IN COLUMN 74.

```
0000M  12345ABRAHAMS, SANDERS L 801231 415701442PHARM      0    0 0 0
```

cols	length	field description
75-76	2	Used by program to keep up with current year. Put a '0' IN COLUMN 76. DON'T under any circumstances put a year in this field for new badges.
77-78	2	Used by program to keep up with current month. Put a '0' IN COLUMN 78. DON'T under any circumstances put a month in this field for new badges.
79-138	60	12 5-digit fields of shallow dose reported this year (most recent month first; NR means no reading). LEAVE THIS ALONE. In setting up a new record this MUST BE LEFT BLANK.

```
0000M  12345ABRAHAMS, SANDERS L    801231 415701442PHARM    0    0 0 0
```

cols	length	field description
139-198	60	12 5-digit fields of penetrating dose reported this year (most recent month first; NR means no reading). LEAVE THIS ALONG. In setting up a new record this MUST BE LEFT BLANK.

BURROUGHS WELLCOME CO.

RADIATION PROTECTION DEPARTMENT

DOSIMETRY STANDARD OPERATING PROCEDURE

APPENDIX B

Algorithm for Burroughs Wellcome Co. Personnel Dosimetry Services

by

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Glenn Hudson

School of Public Health

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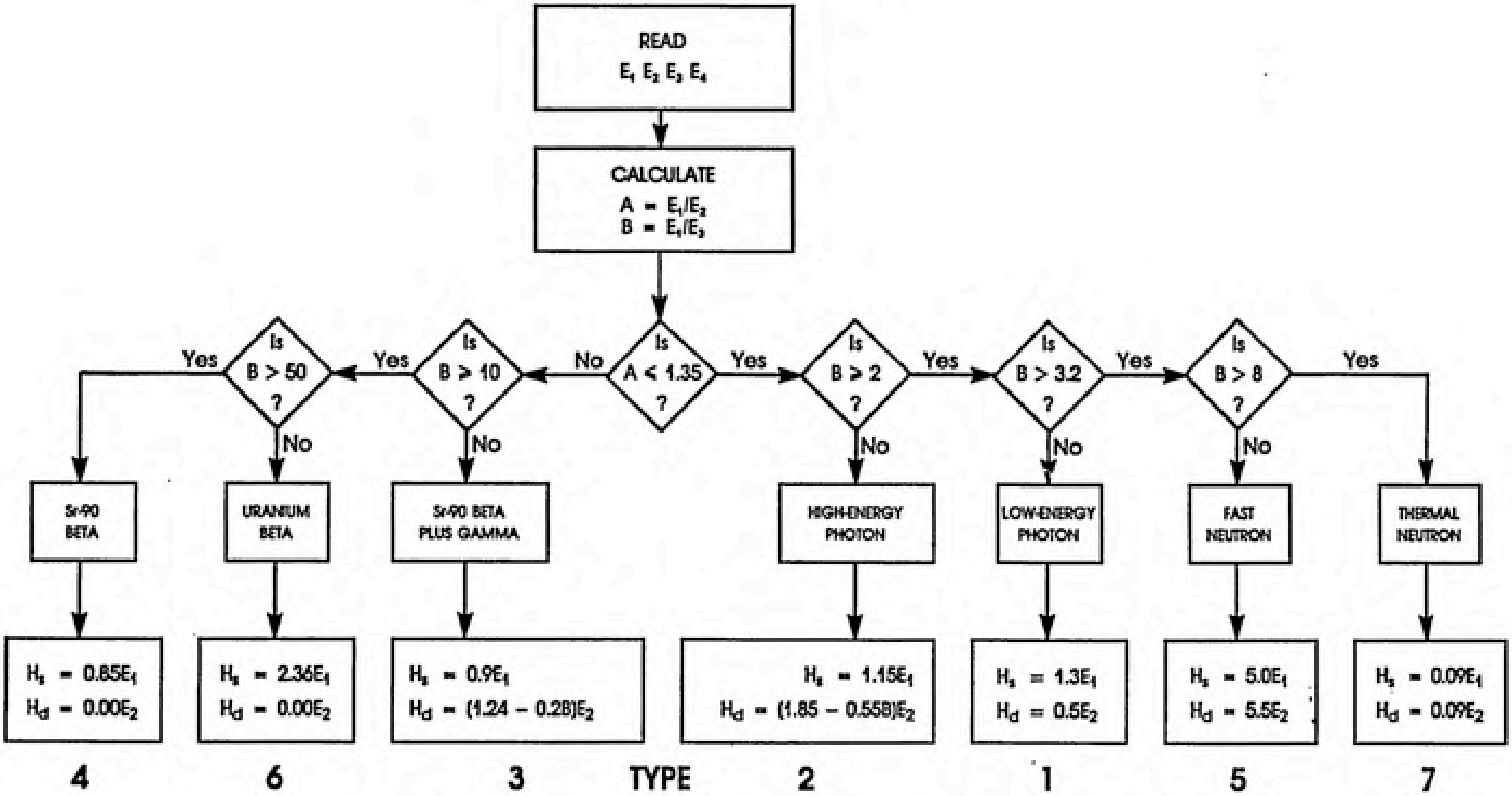
Ann Arbor, Michigan

1979

Appendix B



Flow chart of the method used to determine the type of radiation to which a dosimeter was irradiated and the equations used to calculate the shallow (H_s) and deep (H_d) dose equivalents.

References

Bu82 Burroughs Wellcome Co. Introduction Pamphlet, August 1982, 2-3

Am83 American National Standard, Personnel Dosimetry Performance Criteria for Testing, September 1982, p. 10

National Bureau of Standards, National Voluntary Laboratory Accreditation Program, Dosimetry LAP Handbook, August 1983

Operating Instruction Manual, Model UD-710A Automatic TLD Reader, Matsushita Electric Industrial Co., LTD

User's Manual for the Panasonic UD-710 Automatic TLD Reader and the UD-702 Manual TLD Reader

Carolina Power and Light Company's Dosimetry Laboratory Instruction Manual, July 1984

Operation of a Condenser R-meter, Victoreen and Associates, August 1984