QUALITY ASSURANCE PACKAGE FOR ROUTINE THERMOLUMINESCENCE DOSIMETRY PROGRAM

R. A. Tawil, G. Bencke, and M. Moscovitch
HARSHAW
Crystal & Electronic Products
6801 Cochran Rd.
Solon, Ohio 44139

ABSTRACT

The Quality Assurance Package presented here specifies a set of reader-related hardware diagnostics and calibration procedures and automatically maintains audit trails of generated and derived thermoluminescence data. It specifies acceptable performance criteria for the reader and dosimeter assemblies; tracks and controls Readout Cycle Temperature Profiles; and ensures that the acquired data is verified.

The quality of the generated glow curves is tracked by the real-time application of Computerized Glow Curve Deconvolution to reference dosimeters that may be mixed with field dosimeters during readout sessions.

This package is supported by a menu-driven software system using vertical auto-selection menus, lotus-style horizontal menus, data entry menus with automatic error checking, and pop-up windows. The menu system is supported by an extensive HELP file; data EDITING is password-protected, and a journal is maintained for each editing session as part of the audit trail. Files for the Raw Data and Derived Dose results are maintained and managed in seven databases.

The paper provides an in-depth analysis of each of the procedures, specifies data validation criteria, and presents samples of the reports generated.

I. GENERAL DESCRIPTION

The objective of this paper is to describe the Quality Assurance Package of the Radiation Evaluation and Management System (TLD REMS) software system originally developed by Harshaw for personal dosimetry applications.

The TLD-REMS software system was developed to control the reader operations, including the acquisition, storage, processing (including dose computation), retrieval, reporting, and disposition of TLD data. The REMS is an integral part of a thermoluminescent dosimetry (TLD) workstation which includes a personal computer and one or more TLD Card Readers in a configuration such as that shown in Figure 1. It accommodates the characteristics of several different readers and provides a common interface to a central computer system. The REMS is designed to operate under DOS or under a UNIX multi-user environment. Password security is required for certain functions of the REMS and a Utility is provided to enable the user to add, delete, and change password hierarchies. A user without a password may generally access data for viewing. With password security, the user may also edit various data, change the data acquisition set-up parameters, and change the Time-Temperature Profiles (TTP) applied to the TL element by the reader during the data acquisition cycle. Data can be archived to a diskette, restored from diskette, and deleted from the system. However, no data can be deleted from the data base unless it has first been archived. The system is menu driven using vertical and panel style menus, pop-up menu windows, and data entry panels with automatic error checking, and is supported by an extensive help message system. Four color pallets are utilized to enhance the utility and interpretation of menu items.

REMS stores the instrument calibration data and the corresponding Readout TTP, reader performance and quality control related data as produced by the instrument during its operations, dosimeter element correction data, glow curves, and computed exposures. Exposure data is stored in the TLD data base in sets of records known as Group Files. Data may be selected from the data base for review and disposition by Group and by certain characteristics of the data itself. The standard data bases are as follows: Group Files, Group Summary File, Quality Control Dosimeters, Element Correction Coefficients, Reference Light, PMT Noise, Electronics Quality Control, and Log Files. This last database is a collection of the comments made by the operator at the initiation and termination of activities that utilize the REMS acquisition functions.

The Quality Assurance Package described here was developed to offer users sufficient capabilities to ensure the validity, reproducibility, and traceability of the data bases maintained. It consists of procedures for Reader Quality Assurance, and procedures to monitor and control the performance of the Reader during the Acquisition of TL Data.

II. READER QUALITY ASSURANCE

The instrument Performance Quality Assurance consists of the Electronics QC, Reader and Dosimeter Calibration procedures, and procedures to exercise and test the different subsystems of the TL Data Acquisition System. The last set of procedures enables the operator to specify operating tolerances during the routine operations of the Reader. A summary of these procedures is presented in Figure 2.

The Electronics QC function polls the electronics subsystem parameters that affect the conversion of the TL-generated light to charge pulses represented by the Glow Curve. The parameters are identified in Figure 3, and serve to determine that the instrument is properly adjusted. By means of the Execute Photronics Calibration option, the operator maintains the reader's electronic adjustments, monitors the data from the acquisition system, and interactively calibrates the current-to-frequency Digitizer/Interpolator electronics. Furthermore, these activities enable the operator to define and establish reader performance criteria for those parameters which are automatically monitored during the data acquisition cycle of the Reader while in normal production dosimetry operation. A complimentary function is the Daily QC. The operator invokes this function at Power Up or according to a pre-established schedule in order to perform diagnostics on the reader hardware including the RAM, PROM, and REFERENCES, and to generate the report shown in Figure 3.

The Reader Calibration option is used to establish the Reader Calibration Factor (RCF), or the average response of the reader to a subset of Calibration Cards created from the Generate Calibration Cards. The purpose of this procedure is to establish Element Correction Coefficients of a set of cards relative to the mean of their response and without reference to a specific Reader calibration. To generate a set of Calibration Cards, the selected cards are cleared and exposed to a known radiation, D_0, and read out in the normal manner. For each element position j of card i, the average response, Q(j), is computed and used to generate element correction coefficient ECC(i,j), according to:

$$ECC(i,j) = \frac{Q(j)}{Q(i,j)} ,$$

Q(i,j) is the reported charge for element j of card i.

To establish the RCF, a statistically representative number of Calibration Cards is cleared, exposed to a known amount of radiation, and read out. An average response for each position on the card is computed according to the following relationships:

$$RCF(j) = \frac{<(Q_0)_j>}{D_0}$$

$$<(Q_0)_j> = \frac{\sum_{i=1}^{k} (Q(i,j)*ECC(i,j))}{k}$$

Where:

RCF(j) - Reader Calibration Factor for card element position j

D_0 - Nominal Irradiation Value

ECC(i,j) - the Element Correction Coefficient for dosimeter element j of card i

k - total number of cards included in the sample

Note that the RCF thus generated is specific to the Time-Temperature Profile (TTP) applied during the Readout Cycle. For the rest of this paragraph, reference is made to Figure 4, which identifies the set of parameters defining the TTP. It is obvious that the $<(Q_0)j>$ value is dependent on the selections made for the Calibration Region values, the preheat temperature and its duration, the maximum temperature attained, the acquisition period and the temperature ramp rate.

Traceability to an NBS Standard may be established according to the following procedure. A statistically representative number of <u>Calibration Cards</u> is cleared and exposed to an absolute dose D_0' at a facility with an NBS standard. The cards are read out in an uncalibrated reader after the application of the Electronics QC Procedures; the average response <Q(j)'> for each element position (j) is computed as previously specified. The same set of cards is then exposed to a nominal value D_0 by the local irradiation facility and the corresponding <Q(j)> is computed. The ratio of <Q(j)>/<Q(j)'> when folded in by multiplying with the RCF provides the traceability. This procedure must be repeated any time the local irradiator configuration is altered or changed.

Another menu item is the <u>Card Calibration</u>. Its purpose is to create an Element Correction Coefficient (ECC) for each dosimeter element on every card in the system in order to normalize their responses. To generate ECCs, all cards are cleared and exposed to a known radiation. The cards are then read using a calibrated reader. The ECC(i,j), position j in card i, is the ratio of the 'nominal irradiation value' to the measured response. The computation process is initiated and proceeds automatically, rejecting any cards with a sensitivity outside the limits set by the operator as acceptable.

III READER MONITORING DURING READOUT CYCLE

The parameters that are monitored and the procedures that are applied during the Readout Cycle are summarized in the Acquisition Setup Menu, Figure 5. Access to this menu for the purposes of data editing is password protected since the values here are utilized to check the reader for acceptable performance. Among the conditions which are set here are the PMT Noise Check Interval and the corresponding acceptable performance range for each element position on the card. The same logic is also applied in monitoring the Reference Light. These two checks are applied to determine the performance of the PMT and the electronic gain stability of the system. This data is maintained by REMS in independent data bases.

Data quality and integrity during acquisition are further assured by means of a hierarchical system of messages exchanged between the reader and REMS. Perhaps the most significant tracking by the system is the instantaneous temperature of the hot gas during the read cycle, which is applied to control the heater logic and is displayed on the system screens in real time. Additionally, the instantaneous temperature and corresponding digitized light output pairs are stored in the database. The glow curve record includes 200 pairs of temperature and intensity values, generating the display seen in Figure 6. During acquisition of these values, several reliability tests are being performed. These include checking the various sensors; checking for an electronic circuit failure; and deviation of more than 10^{o} C in heater temperature from the control input signal. If the system fails any of these reliability tests, orderly shutdown is initiated with the appropriate error messages displayed.

The last procedure of the Quality Assurance Package that will be discussed here is the application of COMPUTERIZED GLOW CURVE DECONVOLUTION TO QC CARDS (CGCD). QC cards are a set of cards that are selected from the Calibration Cards, exposed to a known dose, and inserted in line with other cards while prepared for Readout. The QC cards are identified by the system, and deconvolution is applied immediately after the Glow Curve generation is completed. CGCD enables tracking and determining the stability of the Glow Curve Peak Positions, reflecting the repeatability of readout cycle temperatures; the Peak Width, reflecting the efficiency of heat transfer from the heater to the TL element across the protective cover; and the Peak Heights, reflecting the stability of the gain of the reader. These are checked against the tolerances specified in

Figure 5, with the appropriate actions taken. This figure also shows the five dose thresholds used to control the disposition of the TLD data records received while processing cards. These thresholds apply to Field Cards only. If any of the TL elements on the card exceed the specified level, the action described will be triggered.

<u>Summary</u>

The Quality Assurance Package described herein features three sets of functions that are invoked in preparation of the reader or during Field Card or dosimeter readout sessions. One set of functions is aimed at calibrating the reader subsystems; the other set addresses the various calibration procedures aimed at establishing traceability of the data generated; and the third is aimed at monitoring and tracking the TL Readout Cycle stability and efficiency during routine operations.

This Package is incorporated in a system, REMS, that is menu-driven using vertical, auto-selection menus, lotus-style horizontal (panel) menus, data entry panels with automatic error checking, and pop-up windows. The menu system is supported by an extensive help file.

<u>Acknowledgments</u>

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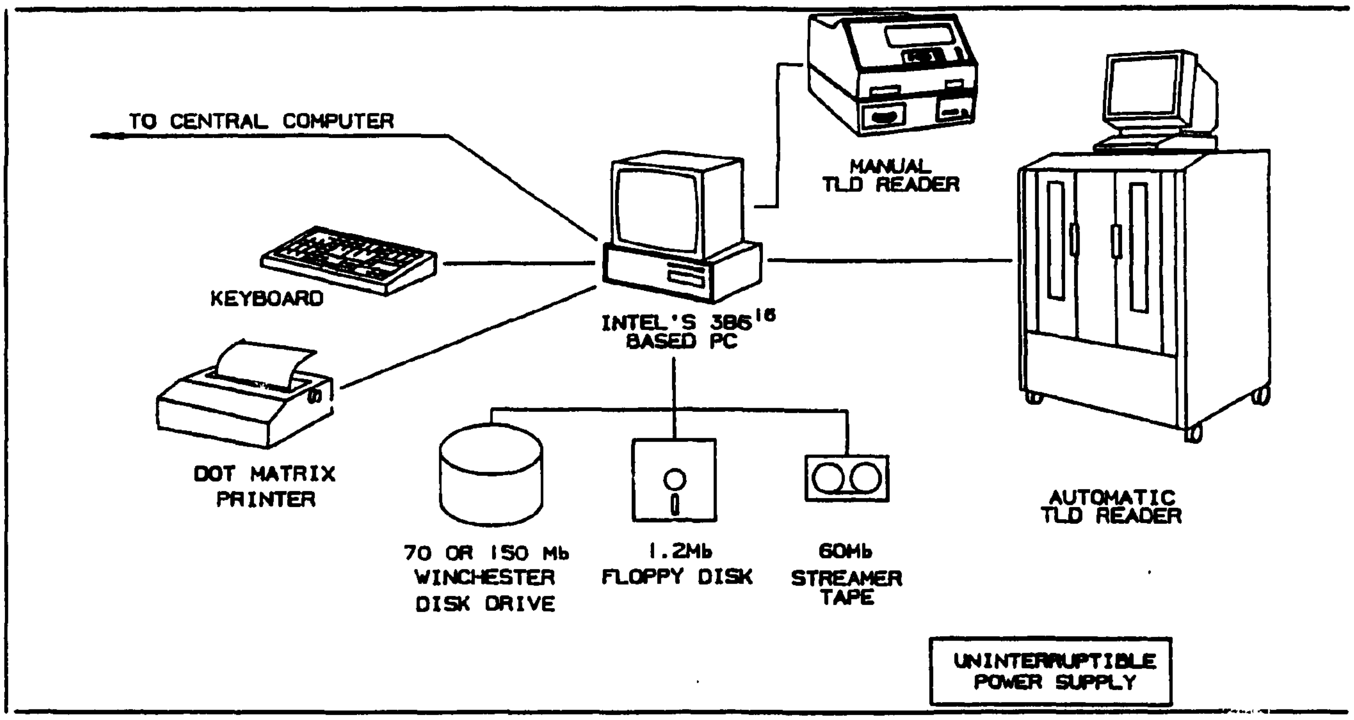

Figure 1
Typical TLD Workstation

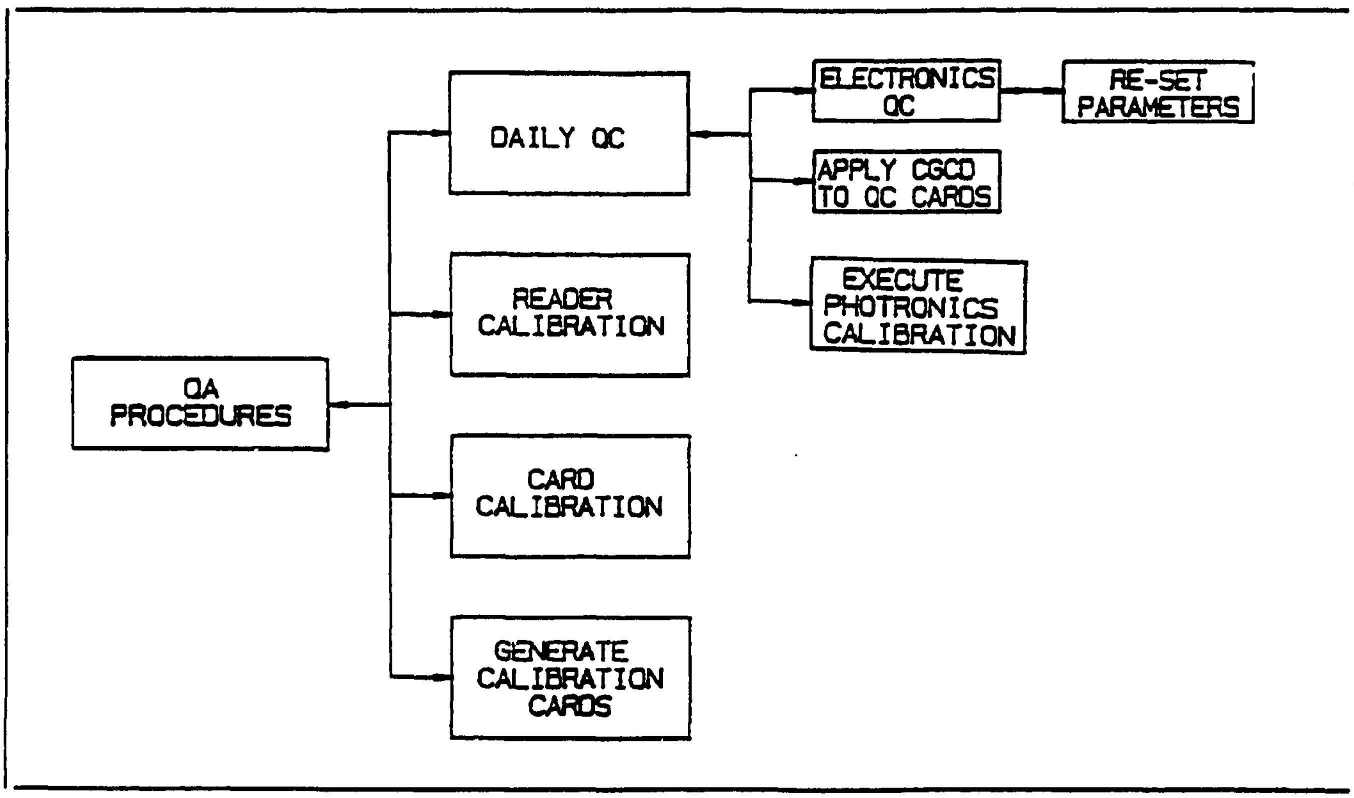

Figure 2
TLD REMS Q A Procedures

Daily Q C	Customer Name	14-Sep-1988 10:27 pm
Electronics Q C	Harshaw TLD-REMS	

Date 14-Sep-1988 Time 22:17:45 Reader Number 16

	(i)	(ii)	(iii)	(iv)
Photronics Version	15	15	15	15
RAM Read/Write test	pass	pass	pass	pass
PROM Checksum test	pass	pass	pass	pass
Plus 15 volt supply	pass	pass	pass	pass
Minus 15 volt supply	pass	pass	pass	pass
D/A Reference test	pass	pass	pass	pass

	Mean	SDev	Mean	SDev	Mean	SDev	Mean	SDev
Temperature	28.3	0.36 %	31.00	0.00 %	29.29	0.00 %	30.02	0.00 %
High Voltage	853	0.03 %	918	0.00 %	899	0.00 %	827	0.00 %
Plus 15 Volts	14.87	0.02 %	14.93	0.02 %	14.95	0.02 %	14.95	0.00 %
Minus 15 Volts	14.99	0.00 %	14.90	-0.0 %	14.88	0.00 %	14.89	0.00 %
D/A Reference	0.190	0.03 %	0.183	0.00 %	0.188	0.00 %	0.183	0.00 %
Ground	-0.03*	0.00	-0.00*	0.00	0.004	0.00	0.004	0.00
Reference Light	159.9	0.61 %	240.1	0.64 %	170.2	0.99 %	185.6	1.02 %
PMT noise	0.144	0.46 %	0.195	9.89 %	0.258	3.11 %	0.113	0.32 %

Start Electronics Q C PrtScrn Re-set Parameters Return to Daily Q C

Figure 3
Electronics QC Report Screen

Data Acquisition	Customer Name	14-Sep-1988 11:08 pm
Time Temp Profile	Harshaw TLD-REMS	

Date Edited 12-Sep-1988 Edited by WILDER
Calibrated 12-Sep-1988
Profile 10 Title plain cards

	(i)	(ii)	(iii)	(iv)
roi1	[1 , 50]	[1 , 50]	[1 , 50]	[1 , 50]
roi2	[51 ,100]	[51 ,100]	[51 ,100]	[51 ,100]
roi3	[101 ,150]	[101 ,150]	[101 ,150]	[101 ,150]
roi4	[151 ,200]	[151 ,200]	[151 ,200]	[151 ,200]
Calibration Region	[1 ,200]	[1 ,200]	[1 ,200]	[1 ,200]
Preheat temperature	30	30	30	30
time	0	0	0	0
Temperature rate	30	30	30	30
Maximum	300	300	300	300
Acquire time	10	10	10	10
Anneal temperature	0	0	0	0
time	0	0	0	0
Calibration factor	1.058	0.961	0.359	0.891 nC/gU
Average PMT noise	0.1943	0.2081	0.3023	0.1624 nC
Average Reference light	159.66	237.01	167.34	190.36 nC

Next Previous Undo Restore Report Return

Figure 4
Time Temperature Profile Screen

Note: Data on these two Figures are included for illustrative purposes only, these values may not be realistic for most cases.

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Data Acquisition                    Customer Name              14-Sep-1988  11:10 pm
Acquisition Set-Up                 Harshaw TLD-REMS

       Date Edited   14-Sep-1988                         Edited by  WILDER

PMT Noise Interval 10                              Reader Record Glow Curves
Ref Light Interval  8                             Display Format Glow Curves
 Apply Calibration none                             Print Format Computed Exposure
                                                 Transmit Format noTransmission


                          ( i    )       ( ii   )       ( iii )        ( iv   )
PMT Noise Range [    0 , 200 ] [    0 , 200 ] [    0 , 200 ] [    0 , 200 ] pC
Ref Light Range [  100 , 150 ] [  100 , 150 ] [  100 , 150 ] [  100 , 150 ] nC
  QC Card Range [  250 , 350 ] [  250 , 350 ] [  250 , 350 ] [  250 , 350 ]

                      If reading  exceeds:
                      9000000 , halt machine and sound alarm
                       800000 , re-read same dosimeter
                         1000 , mark record with warning flag
                            0 , for [ Cal. Region ] save curves and exposure
                            0 , for [ Cal. Region ] save exposure only


                                Return to Acquisition
```

Figure 5
Acquisition Set-up Screen

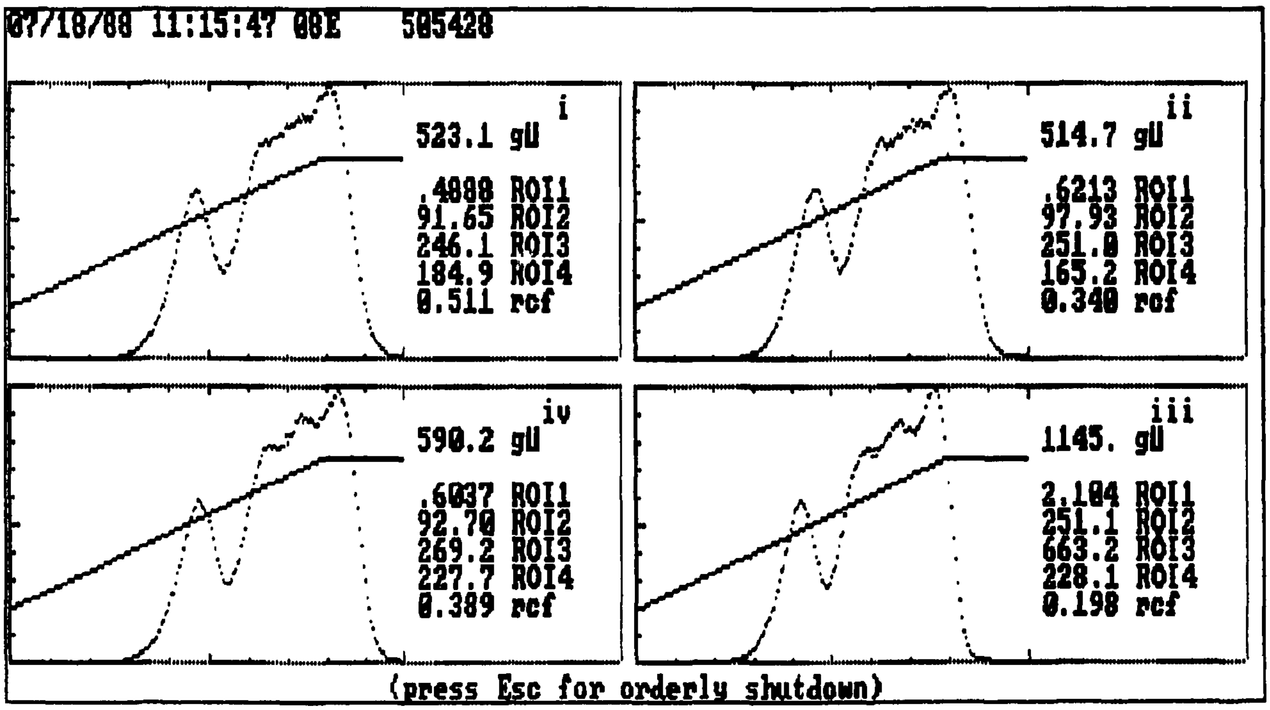

Figure 6
Glow Curve and Temperature Display Screen

Note: Data on these two Figures are included for illustrative purposes only, these values may not be realistic for most cases.