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Experiences in establishing TLD based Personnel Monitoring Laboratory at Kudankulam Nuclear Power Project

Jashi K.B, Ashok Kumar A, Pandaram P

TLD Laboratory, Kudankulam Nuclear Power Project, Kudankulam 627106, India

Abstract

Thermoluminescent Dosimeter (TLD) based on $CaSO_4$:Dy is used as Personnel Monitoring Device for the radiation workers at Kudankulam Nuclear Power Project (KKNPP). A new TLD Laboratory at KKNPP site was established and accreditation was obtained from Bhabha Atomic Research Centre (BARC). The experience gained during the progress is summarised.

Keywords: *Personnel Monitoring Services; Thermoluminescent Dosimeter; TLD badge reader.*

PACS Code: Thermoluminescence, 78.60.KN

1.0 Introduction

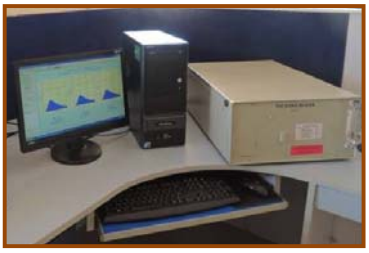
Personal monitoring is one of the vital aspects of the radiation protection and forms the basis for the two of the three basic principle of radiation protection viz 'optimization' and 'dose limit', while justification needs to be considered before taking up any activity related to radiation exposure. Therefore, for the Nuclear Power Plants, personal monitoring is the basis of radiation protection. Personal monitoring encompasses measurement of external as well as internal dose, its assessment, analysis of dose data correlation with other information and assessing the reasons for changes in exposure pattern which provide the ways for reduction of individual dose. This is duly reflected in the objective of personal monitoring as defined by International Commission on Radiation Protection (ICRP-75).

Kudankulam Nuclear Power Project consists of 2 x 1000 MWe advanced Generation III+ Russian Pressurised Water Reactors (PWRs). Operational experience of Boiling Water Reactor and PWR shows that control of external dose is a main objective of radiation protection as the internal exposure component is very small, when compared with the Pressurised Heavy Water reactor. Indigenously developed. Thermoluminescent Dosimeter (TLD) is used to monitor and control the external exposure in all Nuclear Power Plants (NPP) in India and similar facility with latest technology and equipment were planned to be commissioned at KKNPP. A proposal for setting up a new TLD Laboratory at KKNPP site was initiated by KKNPP in technical collaboration with Radiological Physics & Advisory Division (RPAD), Bhabha Atomic Research Centre (BARC). It was the first lab established by Nuclear Power Corporation of India Limited (NPCIL) and accredited by BARC as per the Memorandum of Understanding between BARC and NPCIL dated July 03, 2012. The experience gained during establishment of the TLD laboratory is summarized below.

2.0 Infrastructure Development

The layout of TLD lab is designed and built to meet the present and future requirement of personnel Monitoring Services (PMS) at KKNPP.

Concept of providing uninterrupted supply of Nitrogen gas using Multi Channel Nitrogen Gas Distribution System (MCNGDS) and Uninterrupted Power Supply System for TLD processing were considered and commissioned. In addition, a customized auto irradiator facility is commissioned which facilitates accurate dose delivery, reproducible geometry and reduction of operator dose.

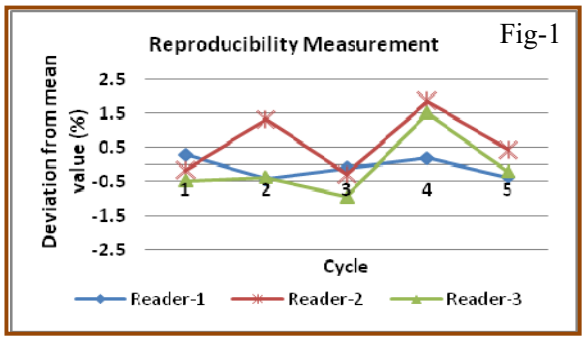


3.0 Commissioning of personnel Monitoring System

Three TLD badge readers were commissioned after subjecting to various tests such as reproducibility, Linearity test, etc as per the Handbook [1]. The system is PC based, capable of loading 50 dosimeters in a magazine and facilitates non contact N_2 gas heating, requires only 30 seconds to read a disc, minimum measurable dose (50 µSv) and generates glow curves as a permanent record. The imperative parameters of readers observed are given below.

3.1 Reproducibility

The performance of a TLD system is assessed by measuring the reproducibility of the system which includes the dosimeter, reader, annealing and irradiation. It is evaluated by calculating the standard deviation of a repeated set of measurements on number of dosimeters selected randomly and subjected to annealing, irradiation and reading cycle under the same



exposure and reading parameters. The reproducibility measurements are shown in Fig-1.

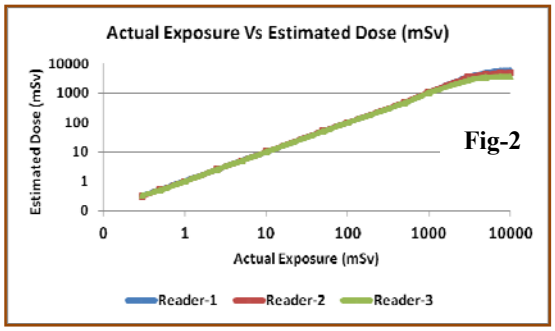
Coefficients of variation viz; System variability index (SVI), which is the mean value of the percentage standard deviation of each detector; Reader variability index (RVI), which is the mean value of each cycle of readings and Detector variability index (DVI) which is calculated as the square root of the difference between SVI and RVI, both squared were calculated. The reproducibility parameters observed are given in Table-1

Table-1

Reader #	SVI	RVI	DVI
1	3.11	1.15	2.89
2	3.06	1.84	2.45
3	2.10	1.91	0.89
TLD Lab	2.73	1.63	2.18

3.2 Quantization of Linearity zone

TLD system comprising of TLD cards and reader is known to have a range of linearity which is the operating range of the system. It is essential to determine the range of linearity of the system to enable proper monitoring as well as for other applications. For this purpose, freshly annealed cards were exposed to various doses viz., 0.30, 0.50, 1.0,



2.5, 5.0, 10.0, 50.0, 100, 500, 1000, 3000, 5000, 7500, 10000 mSv using an auto irradiator system. The TL response (average TL/mSv) should be within ± 10% in the entire dose range covered. Linearity zone of dose measurement and saturation dose limit of all the three TLD readers have been established (Fig-2). All the three systems have shown linearity upto 1 Sv, which is well below the level of dose received by radiation workers at NPPs during normal operation and maintenance activities and the Coefficient of linearity values observed are given in Table-2.

Table-2

Reader #	Coefficient of determination (R^2)	Coefficient of Linearity (COL)
1	0.997	0.8%
2	0.998	5.4%
3	0.998	1.6%

4.0 Accreditation of TLD laboratory:

TLD Lab was commissioned in October 2011 and subsequent to commissioning of TLD lab, an application form for carrying out Personnel Monitoring Services (PMS) was sent to Head, RPAD, BARC and RPAD officials made a **pre-accreditation On Site assessment** visit to the Lab, examined the documents, Infrastructures available and also conducted a **proficiency test**. The performance of the TLD lab, KKNPP was found to be satisfactory and met the requirement of accreditation. Subsequent to the successful completion of the inspection, TLD Laboratory at KKNPP was awarded a certification of accreditation in the year 2012.

5.0 Quality Assurance (QA) Programme

Since commissioning of TLD Lab, more emphasis is given to QA programme at TLD Lab, KKNPP to

ensure smooth functioning of all systems for qualitative and quantitative assessment of external exposure. It consists of internal QA checks at Lab, External QA check by BARC and Blind test by Health Physics Unit for ensuring qualitative and quantitative measurement of exposures of the radiation workers.

5.1 Internal QA check

5.1.1 TLD Readers

- EHT to PM Tube: Variation is within the acceptable value of ±1V
- Light Source Reading: Variation is within the acceptable value of < 2%
- Light Leakage: No light leakage was observed
- Reader timer: Timer reproducibility is of ±1Sec
- Readout Temperature: 285°C ± 2°C
- Glow Curve (GC) & Uniformity in Readout
  a. GC peak position: Value is within the acceptable range of 9-12 seconds
  b. GC Tail to peak ratio: Value is below 25 % and is acceptable
- Residual TL Check: Value is within the acceptable range of 8-12 %
- Minimum Detection Threshold using service cards: 19.7, 15.4 & 18.0 µSv for Reader 1, 2 & 3 respectively.
- Minimum Detection Threshold using virgin cards: 16.6, 13.8, 10.8 µSv for Reader 1, 2 & 3 respectively.
- Reproducibility of the TL Readout: DVI for TLD lab is 2.18 (Table-1) and is satisfactory
- Linearity Test: Coefficient of linearity of the three systems are below 6% (Table-2)

5.1.2 TLD cards

New TLD cards procured were subjected to initial quality assurance (QA) check prior to acceptance. The initial Quality Assurance check consists of Physical inspection and individual testing of TL sensitivity of TLD cards.

The physical inspection of the TLD cards are:

a) Discoloration of the disc
b) Presence of foreign particle
c) Voids and spots on the disc
d) Dislocation of TLD disc around the clips
e) Proper clipping of the disc
f) Centering of disc position on the respective holes in the TLD cards

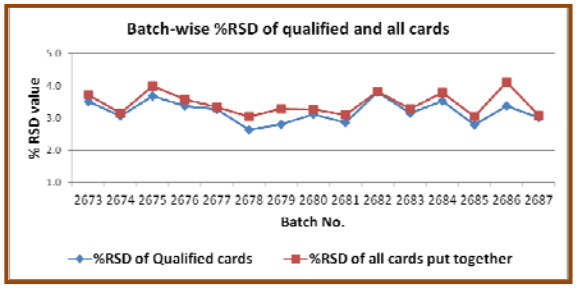
During Physical inspection, a total of 405 number of TL cards (minimum of 25 cards from each batch) from the total lot of 3000 cards were checked for Physical dimension and appropriateness of clipping and centering of discs in the cards. A total of 70 out of 3000 cards were rejected in physical inspection.

Subsequent to physical inspection, all the TL cards were subjected to individual sensitivity check. The following acceptance criteria were applied to the TL cards and about 243 TLDs cards were found to be disqualified.

Criteria-1. Disc to disc variation of each TL card shall be within ±5%

Criteria-2. Sensitivity of each disc of a card shall be within ±10%

- The batch-wise **%RSD** (Relative standard Deviation) of the qualified cards were found to be in the range **of 2.6 to 3.8** and is graphically shown below.



- Physical verification of all cards is being checked after every cycle.
- Periodic sensitivity check: TLD cards in the field use are checked after completion of every 5 cycles to avoid any significant reduction (15% as compared to the reference cards) in sensitivity of the batch.

5.1.3 Annealing Oven

- Temperature profile of Oven is checked by using platinum resistant temperature detectors (RTD) Pt100 and the temperature was found to be within ± 2°C.
- Verification of Proper Annealing: Appropriateness of annealing is verified after every annealing by taking readout of 5% of cards and the background reading is found to be in the range of 30 to 50 µSv.

5.1.4 Nitrogen gas supply system

The purity of the nitrogen gas is checked every quarter and it is found to be in the range of 99.11 to 99.47%.

5.2 External Quality Assurance check

5.2.1 Performance test conducted through post

Performance test is conducted by RPAD, BARC. A total of 54 numbers of TLD cards from field use are sent to RPAD, BARC and the cards were returned after exposure to radiation by BARC. The cards were

readout at TLD lab, KKNPP and the results submitted to RPAD, BARC. RPAD, BARC analyzed the results using the ANSI 2009 criteria [2] as well as by the method of Trumpet curve [3] and the performance status report was sent with recommendations. Summary of Performance of TLD Lab, KKNPP as per ANSI 2009 criteria for Gamma radiation for last three cycles of external Quality Assurance Check (QAC) is given in Table-3.

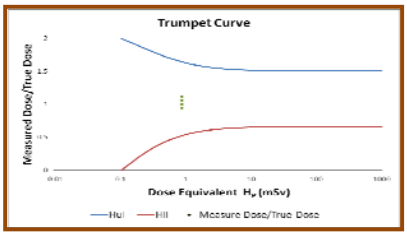
Table-3

Cycle (Year)	B	S	L	Status
38 (2012)	-0.09	0.05	0.10	Satisfactory
39 (2013)	0.01	0.14	0.14	Satisfactory
40 (2014)	0.04	0.09	0.10	Satisfactory

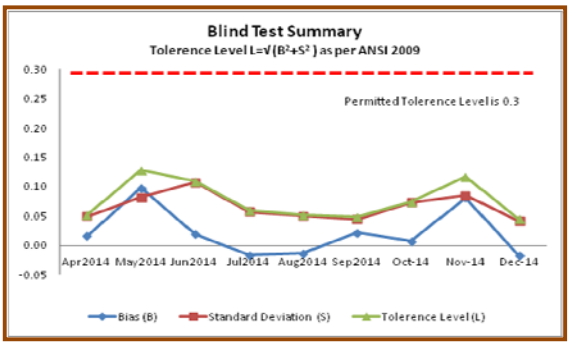
B-Bias; S-Standard Deviation; L- Tolerance level which is below the acceptable value of 0.3.

5.2.2 Blind test

Blind test is conducted every month by Health Physics Unit (HPU). For this, 20 cards were picked up from the service cards and fake names were assigned after exposure by HPU. The cards were returned along with service cards and the result of the dose report is analyzed as per ANSI 2009 [2] and ISO trumpet curve [3].



Blind test results of the year 2014 are shown below.



6.0 External Auditing

6.1 On-site Assessment by RPAD, BARC

An inspection team from RPAD, BARC visited the Lab and assessed the functionality of all the instruments, equipments, calibration, procedures adopted and correctness in record keeping. In addition**, a spot assessment** test was also conducted as a part of On-site assessment to demonstrate the **proficiency** in the performance of the laboratory. The overall performance of the lab was satisfactory.

6.2 Inspection by Atomic Energy Regulatory Board

Periodic Auditing by Atomic Energy Regulatory Board facilitated continual improvement of the PMS at KKNPP.

7.0 Conclusion

TLD Lab at KKNPP is the first Laboratory constructed and commissioned by NPCIL and subsequently awarded certification of accreditation by RPAD-BARC. This was possible as a result of implementing all the initial Quality Assurance (QA) checks as prescribed by vendors and the standards recommended by RPAD, BARC.

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References:

1. Hand book on the use of TLD Badge based on $CaSO_4$: Dy Teflon TLD Discs for Individual Monitoring (BARC/2002/E/025) by A.S.Pradhan, et al, RPAD, BARC
2. ANSI (2009), American National Standard for Dosimetry - Personnel Dosimetry Performance - Criteria for Testing, American National Standards Institute (ANSI) Inc., New York, ANSI/HPS N13.11-2009.
3. International Atomic Energy Agency (IAEA), Inter-comparison For Individual Monitoring of External Exposure from Photon Radiation, IAEA-TECDOC-1126, Vienna (1999).
4. Instruction Manual –TLD Badge Reader (Type: TL 1010), Nucleonic System Pvt, Hyderabad.