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RADIATION PROTECTION SERVICES DIVISION
PROGRESS REPORT
1992 - 1993

Editors
O. P. Massand and B. K. S. Murthy

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GOVERNMENT OF INDIA
ATOMIC ENERGY COMMISSION

RADIATION PROTECTION SERVICES DIVISION : PROGRESS REPORT FOR 1992-1993

Editors:

O.P. Massand and B.K.S. Murthy
Radiation Protection Services Division

BHABHA ATOMIC RESEARCH CENTRE
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60 Abstract : This report describes the work of the Radiation Protection Services Division during 1993, for implementation of radiation safety in all institutions in the country using radiation sources in medical, industrial and research applications. It gives information about personnel monitoring using photographic film and TLD badges, neutron monitoring badges, advisory and licencing services, regulation, transport of radioactive materials and periodic protection survey. About 33 publications by the staff of the Division are listed.

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PREFACE

The Radiation Protection Services Division was formed in October 1992 and has inherited most of the regulatory functions of the Division of Radiological Protection. The Division conducts the personnel monitoring, advisory and surveillance programmes as well as looks after the safe transport of radioactive materials.

To give some idea of the extent of work carried out during the past year, 43,000 radiation workers were monitored by the Personnel Monitoring Section. A total of 120 cases of excessive exposures among the radiation workers (outside the nuclear fuel cycle) were investigated. The National Dose Registry contains data on more than 1.5 lakh radiation workers over the past 40 years.

The Radiological Advisory Services Section gives advice and provides surveillance to many radiation installations. Installation plans were approved for 100 institutions. 120 radiological protection surveys were done. 1700 authorisations for use of radiation sources and 100 transport certificates for radioactive materials were issued. 121 spent radioactive sources were arranged to be safely decommissioned. Many consumer products containing radioactive materials like gas mantles, watch dials and smoke detectors were routinely measured to check their compliance withs regulations. The Division actively participates in many training programmes connected with radiation safety. The Division also attended to requirements of five radiation incidents.

G. Venkataraman

(G. Venkataraman)
Head, Radiation Protection Services Division

C O N T E N T S

A. PERSONNEL MONITORING SECTION - P.H.Patel

Personnel Monitoring Section conducts countrywide personnel monitoring in 3600 institutions covering about 43,000 radiation workers from nuclear fuel cycle, industrial, medical and research institutions. The section consists of six groups : Film Badge Service (R.V.Dhond), TLD Monitoring Service at Trombay (J.S.Nagpal and U.R.Kini), Neutron Monitoring Service and TLD monitoring at Outstations (O.P.Massand), Criticality Accident Dosimetry (N.P.S.Sidhu) and National Dose Registry (R.K.Kher). Film Badge Service covers about 12,500 radiation workers. TLD monitoring service at Trombay covers about 15,000 workers from B.A.R.C., I.R.E. and medical and industrial institutions of Bombay City, Maharashtra and Goa as well as all research institutions. The Division has set up seven TLD units at TAPS, RAPS, MAPS, NAPS, KAPP, NFC, Hyderabad and VECC, Calcutta. 15,000 workers from DAE institutions as well as non-DAE institutions of Andhra Pradesh and Calcutta city are monitored by these seven units. In addition, about 700 defence personnel are monitored from a TLD unit operated by INMAS, Delhi. 1250 persons from 56 institutions are monitored for fast neutrons and 300 criticality accident badges have been issued to various BARC and DAE units. Dose Records of all the radiation workers are centrally maintained by RPSD at the National Dose Registry.

The Section participated in the International Intercomparison of Criticality Accident Dosimetry Systems held at Valduc during June 1993. A member attended an IAEA-RCA meeting on Radiation Infrastructure at Beijing during March 1993. A workshop on individual monitoring was organised by the Section during July 1993 for the benefit of staff members working at outstations. A status report on National Dose Registry was submitted to UNSCEAR meeting held at Vienna during May 1993. A staff member delivered two lectures on medical physics in the Refresher Course for physics teachers under the UGC scheme. Members of the section were associated with the various training programmes conducted by the Radiological Physics Division and Health Physics Division.

The report describes the R & D activities of the Section as well as dose data analysis. The publications are listed at the end.

1. DOSE DATA ANALYSIS

1.1 NATIONAL DOSE REGISTRY

R.K.Kher

Preparation of lifetime cumulative dose master file and updating of the same upto the year 1992 was completed. This is an important step in the organisation of dose data in the National

Dose Registry. The 8 digit personal number allotted to a radiation worker within an institution is the 'Key' for computer records and the institution is the 'Unit' for all the reports. The code for categorisation of institution as per UNSCEAR report categories (total nos. 27) are maintained in the institution address file. At present, nearly 50% of the overall capacity of the present number system for institution numbers is already allotted. Institutions are required to maintain complete contact address of each radiation worker enrolled under the institution. For records and ready reference, a hard copy of cumulative dose file with yearly breakup in 14 bound volumes has been prepared. Updating of personal data records of radiation workers and allotment of institution numbers and personal numbers to new radiation workers was continued. As part of dose data analysis, work on number of reports/papers was completed during the year. A report on the status of National Dose Registry of India was presented in the UNSCEAR meeting at Vienna during May 17-29, 1993. Programs were modified/adopted for use on PC/AT-286 as old SN-23 system in use has to be phased out due to frequent system breakdown. A new computer system based on EISA 486 PC/AT is to be installed in the beginning of 1994.

1.2 UPDATING OF PERSONAL DATA OF RADIATION WORKERS, ANNUAL DOSE MASTER AND PERIODIC DOSE REPORTS

P.H.Pardasani, V.D.Joshi, J.M.Awari, P.G.K.Nair, S.K.Naik
S.G.Pawar and R.K.Kher

Personal data (PD) of radiation worker forms an essential and important part of the occupational dose records in the National Dose Registry. Allotment of personal number to new radiation workers in an institution is done only after checking the information given on the PD form. Apart from essential details for clear and unambiguous identification, PD form seeks information on qualifications (8 categories), Designation (12 categories, Nature of radiation work (19 categories) and also details of radiation work done prior to joining the current institution through which the form is submitted. PD forms have been received in all for about 30000 persons including about 65% of the presently active radiation workers from Non-DAE institutions, and computer records updated accordingly. Among the inactive Non-DAE workers atleast Date of Birth record is available for about 20% workers. Further efforts are being made to update the PD records of all the radiation workers.

For updating of current annual dose master files, checklists are prepared from the dose data files received on floppies from various personnel monitoring service units. The periodic dose reports are prepared from the checked and corrected batch data files and the current annual dose master file is updated accordingly. Table - 1 shows the annual dose analysis for the year 1992 and Table - 2 shows the summary annual doses from the

year 1956 for the broad categories and total. The average annual doses show decreasing trend over the years indicating overall improvement in radiation safety.

TABLE - 1. ANNUAL DOSE DATA ANALYSIS - 1992

Category	Average Dose mSv	No. of person in percent with annual dose > (mSv) 5	10	20	30	35
Nucl.Fuel Cycle	2.43	15.8	6.6	1.5	-	-
Industry	1.33	6.4	3.3	1.0	0.4	0.2
Medical	0.36	1.3	0.4	0.1	-	-
Research	0.19	0.4	0.2	-	-	-
All	1.37	8.1	3.4	0.8	-	-

TABLE - 2 . SUMMARY OF ANNUAL DOSES
(AVERAGE FOR ONE YEAR IN THE GIVEN 5 YEARS RANGE)

YEARS	MEDICAL MONITORED PERSONS	MEDICAL AVG. (mSv)	INDUSTRY MONITORED PERSONS	INDUSTRY AVG. (mSv)	NUCL.FUEL CYCLE MONITORED PERSONS	NUCL.FUEL CYCLE AVG. (mSv)	ALL[$] MONITORED PERSONS	ALL[$] AVG.[$] (mSv)
56-60	729	4.79	20	0.90	709	3.79	1513	4.15
61-65	3373	3.54	383	3.31	2532	2.49	6555	3.00
66-70	5304	1.75	974	8.86	3246	5.55	10085	3.59
71-75	7119	1.13	1552	3.68	4708	7.14	14145	3.37
76-80	10244	0.76	3207	3.45	6511	7.28	21162	3.15
81-85	11958	0.54	4081	2.43	10409	5.28	27575	2.60
86-90	15930	0.50	5997	2.32	13472	3.91	37264	2.01
91-92	16462	0.40	5536	1.39	17152	2.81	41240	1.53

[$] Including Research Category

1.3 CUMULATIVE OCCUPATIONAL RADIATION EXPOSURE RECORDS IN INDIA

R.K.Kher, P.H.Pardasani, J.M.Awari and V.D.Joshi

The dose records of radiation workers covered by the countrywide personnel monitoring service for the last 40 years are maintained in the National Dose Registry. Cumulative doses of all the radiation workers at the end of 1992 in nuclear fuel cycle, industry, medical and research institutions during the last 40 years are analysed. The average working year for radiation work is about 5.25 years for the workers in nuclear fuel cycle and it is about 4 years for workers in the other categories. Table - 3 shows the distribution of working years in

various categories. In each category about 70 to 80% workers have worked for five years or less. About 8% of workers have worked for more than 15 years in Nuclear Fuel Cycle category. The average cumulative dose for all the radiation workers together is only about 11.9 mSv and less than 3% workers have cumulative doses exceeding 100 mSv. Table - 4 shows the summary of cumulative dose data upto 1992 for all the radiation workers in various categories. The percentage of persons recording zero cumulative doses are about 16%, 36%, 27% and 55% in the Nuclear Fuel Cycle, Industry, Medical and Research categories respectively. These values are substantially lower than the estimates of possible lifetime cumulative dose values even with reduced dose limits following ICRP-60 (1991) recommendations. The contribution of various categories to the cumulative collective dose of the monitored persons is Nuclear Fuel Cycle 67.5%, Industry 15.4%, Medical 16.5% and Research 0.6%.

For persons who started radiation work during 1971-80 and 1981-90, it was noted, the average cumulative doses are about 2/3 and 1/3 respectively of the average cumulative dose of those who started radiation work during 1961-70. The maximum cumulative person dose has not exceeded 400 mSv for the persons who started radiation work after 1980. For persons starting radiation work in earlier years, only a few cases have cumulative doses above 400 mSv. However, all the cumulative doses are well below 1000 mSv. These observations indicate overall improvement in radiation safety over the years following the changes in the emphasis and recommendation of ICRP.

TABLE - 3. Distribution of working years with number of persons (in percent) in various Categories

	No.of Instn.	No.of persons	Persons (in percent) with working years ≤5	≤10	≤15	≤20	Actual number >20
Nucl.Fuel Cycle	96	46199	69.3	85.7	91.8	95.8	1958
Industry	803	21513	78.2	92.6	97.3	99.2	167
Medical	3585	75632	81.2	93.5	97.3	98.8	873
Research	375	7919	79.6	93.5	97.4	98.9	84

Table 4. Cumulative Dose Data for all the Radiation Workers in various categories upto 1992

Broad Category	Average Cumulative dose (mSv)	Persons (in percent) with cumulative dose in excess of - 10 (mSv)	30 (mSv)	50 (mSv)	100 (mSv)	300 (mSv)	500 (mSv)
Nuclear Fuel Cycle Industry	26.93	29.1	16.2	12.2	7.4	1.9	0.5
Medical	12.60	19.1	9.5	5.9	2.5	0.2	-
Research	3.86	7.4	2.5	1.2	0.4	-	-
All	1.24	2.4	0.5	0.2	-	-	-
	11.90	15.3	7.5	5.1	2.8	0.6	0.2

1.4 ANALYSIS OF OCCUPATIONAL DOSES OF FEMALE RADIATION WORKERS

P.H.Pardasani, V.D.Joshi, J.M.Awari and R.K.Kher

Analysis of annual occupational doses of the female radiation workers, as a group, has been done, as a matter of general interest. In India female radiation workers constitute about 5% of total radiation workers monitored every year. However, in the medical and research categories they constitute about 10% of the radiation workers.

The average annual dose data for the period 1987-91, was in the range 0.52 to 0.70 mSv for female radiation workers. The average female doses are also analysed as ratio of average dose received by all the radiation workers in the category in that year. For DAE and Industry categories, the ratio varies from 0.2 to 0.4. For Medical category, the ratio varies from 1.33 to 1.67 and for Research category, the ratio varies from 0.85 to 1.2. The agewise dose distribution was analysed and the average dose in various age groups was found to vary between 0.13 mSv to 0.91 mSv It is concluded that average annual doses of the female radiation workers are decreasing marginally and are well within the limits. The average working year for female radiation workers is about 3 to 5 years which is same as that of all the radiation workers on our records.

1.5 ANALYSIS OF BETA, EXTREMITIES, NEUTRON AND INTERNAL DOSES AND THEIR COMPARISON WITH THE CORRESPONDING CHEST DOSES

P.H.Pardasani, J.M.Awari, P.G.K.Nair and R.K.Kher

Yearly dose records for beta,wrist, neutron and internal doses are being prepared for last 10 years from the old yearly master files for our records. Beta exposure and extremities dose data are analysed for the years 1991, 1990 and 1989. Beta doses are reported mainly in the DAE institutions category whereas

wrist doses are reported for DAE, Industries and Medical institution categories. Average values of beta doses and average wrist doses are more than average of the corresponding chest doses for both group of persons. However, the equivalent dose values due to beta or wrist doses are insignificant taking into account the corresponding weight factors. It is concluded that whenever high beta or wrist doses are recorded, it may indicate abnormal working conditions and calls for reviewing of the work procedures.

1.6 TRENDS IN OCCUPATIONAL EXPOSURES TO FILM BADGE USERS

K.S. Shenoy

The dose data analysis of film badge users has been carried out for the categories such as Medical (radiotherapy), Medical (Radiodiagnostic), Industrial Radiography Camera users, and other Industrial users (other than radiography) for the period from 1987 to 1992. The parameters considered for the analysis are

1. Number of total monitored and measurably monitored persons.
2. Annual collective equivalent Dose.
3. Average Annual equivalent Dose.
4. Distribution ratios such as (SR) 15, (NR) 15, (SR) 25, (NR) 25 etc.

Table 1 and 2 summarises the data for the year 1992.

Table 1 : Occupation exposures to Film Badge Users (1992)

Category	No of persons monitored	Ann. Coll equi dose (person-Sv)	Ave dose per person mSv (A)	Av. dose per measurably exposed worker (B)	B/A
Medical	10149	4.301	0.42	1.122	2.58
Radiotherapy	2406	1.315	0.547	1.292	2.36
Radiodiagnostic	7743	2.988	0.39	1.061	2.65
Industry	2528	2.100	0.831	2.925	3.52
Industries using camera	1448	1.859	1.284	3.873	3.02
Other industries	2528	0.241	0.223	1.013	4.53

Table 2 : Distribution ratios of occupational worker using Film badge (1992)

Category	(SR)15	(NR)15 x10-3	(SR)25	(NR)25 x10-3	(SR)35	(NR)35 x10-3	(SR)50	(NR)50 x10-3
Medical	0.16	2.56	0.08	0.69	0.06	0.39	0.03	0.30
Radiotherapy	0.12	2.91	0.05	0.83	0.03	0.98	—	—
Radio diagnosis	0.18	2.45	0.09	0.65	0.07	0.39	0.07	0.13
Industry	0.09	0.79	0.05	3.95	0.02	0.79	—	—
Ind camera user	0.09	15.88	0.04	6.21	0.02	1.38	—	—
Other Indust	0.11	0.93	0.11	0.93	—	—	—	—

The average doses are higher for radiation workers in Industrial radiography compared to workers in Medical institutions. In medical category, persons working in radiotherapy departments receive higher doses as compared to those working in radiodiagnostic departments. It can be seen that in general the percentage of radiation workers receiving annual doses of higher order is small hence the revised ICRP recommendations could be complied with without much difficulty.

Similar data for the period 1987 to 1992 is summarised in tables 3 and 4.

Table 3: Summary of occupational exposures for film badge service industrial radiation worker (1987-92)

Year	Ave.equi.dose per monitored person mSv A	Ave equi.dose per measurably monitored person mSv B	(NR)15 x10-2	(SR)15	B/A
1987	2.23	5.44	3.61	0.479	2.44
1988	2.26	5.63	4.37	0.547	2.49
1989	1.73	4.12	2.6	0.380	2.38
1990	1.24	4.01	2.01	0.348	3.23
1991	0.95	3.06	1.14	0.301	3.22
1992	0.83	2.92	0.949	0.09	3.52

Table 4: Summary of occupational exposures for film badge service medical radiation workers (1987-92)

Year	Ave.equi.dose per monitored person mSv A	Ave equi.dose per measurably monitored person mSv B	(NR)15 x10-2	(SR)15	B/A
1987	0.82	1.80	0.748	0.272	2.195
1988	0.75	1.96	0.457	0.161	2.61
1989	0.76	1.41	0.525	0.212	2.17
1990	0.48	0.89	0.383	0.172	1.85
1991	0.51	1.18	0.69	0.175	2.31
1992	0.44	1.12	0.263	0.162	2.55

Average individual doses and distribution ratios (NR)15 and (SR)15 show marked decreasing trend over past five years indicating general improvement in radiation protection standards. It is also noted that the decrease in doses as well as distribution ratios (NR)15 and (SR)15 is more significant in Industrial radiation workers as compared to medical institutions which could be due to the exercise of stricter control for industrial category.

Analysis of life time cumulative dose for the year 1991 was done for medical institutions. The analysis fits with log-Normal distribution very well. From the distribution, following analysis was done.

$$\log(X) = \log(u) + 1.1513\,[\log(s)]$$

$$\text{where } s = \frac{X84.15\%}{X50\%} = \frac{X50\%}{X15.85\%}$$

from log-normal distribution, values were

$$\mu = X = 1$$

and $X84.15\% = 7$

Hence from distribution curve average life time cumulative dose per person in medical category would be 6.64 mSv.

2. EXCESSIVE-EXPOSURE INVESTIGATIONS

O P.Massand, J.M.Mahajan and R.L.Pandey

The dose equivalent recorded by the personnel monitoring badges in excess of 10 mSv are considered as excessive exposures and are communicated to the respective institutions for

investigations on priority basis. For medical, industrial and research (non-DAE) institutions the excessive exposures are investigated by a Committee appointed by Director, BARC to decide the genuineness or non-genuineness of exposures. On the basis of investigation reports received from the Institutions and other available data the Committee recommends the necessary follow-up action. The persons whose badges record dose equivalents exceeding 100 mSv and whose exposures are likely to be genuine are called to BARC for chromosomal aberration test and medical examination. A total of 158 excessive exposure cases were reported during the year 1992 as presented in the table. During 1993, a total of 122 cases have been reported.

TABLE - Excessive Exposures reported in the year 1992 in industrial, medical and research institutions.

		Dose Range (mSv)					
Year	Category	10.00-19.99	20.00-29.99	30.00-49.99	50.00-99.00	>100	Total
1992	Ind.	35(9)	15(6)	5(2)	7(6)	4(3)	66(26)
	Med.	40(18)	21(13)	15(8)	7(4)	6(6)	89(49)
	Res.	2(2)	-	-	-	1(1)	3(3)

called for CA Test: 3(2) ()non-genuine

In case of DAE Institutions, Internal Committees of the respective units consisting of members from the Unit, Health Physics Unit and a member of personnel monitoring section investigate the excessive exposure cases. The Head of the unit sends the recommendations to the Head, Health Physics Division. For dose equivalents exceeding the annual limit of exposure a senior committee appointed by SARCOP, AERB, further investigates each such case. A total of 144 excessive exposure cases have been reported from DAE institutions by various TLD monitoring units during 1992.

3. R & D ACTIVITIES

3.1 PC BASED SEMIAUTOMATIC FILM BADGE READER

Smt D.Sarala Bai Amma, A.S.Pathak, R.L.Pandey, M.P.Sankaran, Hariom Mittal, R.V.Dhond

The prototype model of the PC based film badge reader, developed in the Division, has been tested for routine use. A conventional single beam densitometer, with a little modification, is used to measure optical densities of the monitoring films. The density output is fed to a PC through an interface.

Several sets of standard lookup tables are created, using nearly 250 calibration films each time, for open, plastic, cadmium, thin copper, thick copper and lead filter for Gamma, Beta, 50 KVp, 75 KVp, 100 KVp, 150 KVp, 200 KVp, 250 KVp x-radiation for both fast and slow emulsion combinations. These lookup tables are required for dose evaluation. The processing of the density data of routine films is done by the PC for dose evaluation.

Measurement and evaluation of personnel monitoring films has been done for several batches using these lookup tables. During the routine use of the instrument, several suggestions were encountered which are being incorporated in the present system.

3.2 QUALITY ASSURANCE OF $CaSO_4$:Dy-TEFLON TAPE DOSEMETERS AND CARDS.

J.S.Nagpal, K.L.Popli, G.Varadharajan, R.K.Kher and A.V.Dere

Tape dosemeters as well as compressed disc dosemeters were examined under an optical microscope for the surface distribution of the $CaSO_4$:Dy phosphor grains and the relative agglomeration. No significant differences in the relative particle size distribution were observed in two types of samples.

A few batches of the tape dosemeters showed a large variation in the TL for unirradiated samples, when read in the presence of fluorescent room lights. Calendering of the skived tape samples reduced the variation in unirradiated TL to a level comparable to the other samples.

Transmission of ^{204}Tl β radiation enables measurement of variations in thicknesses of the order $\pm$ 2 $mg.cm^{-2}$. This thickness variation gives rise to a maximum variation of $\pm$5% in the TL output per unit area of the dosemeters. Measurements of β transmission of dosemeter samples drawn from several batches of skived tape as well as those prepared by compressing technique have given consistent results. The β transmission method itself can be used for quality assurance and selection of uniform set of dosemeters over thickness range of 30-150 $mg.cm^{-2}$.

TL response of the tape dosemeters to β and gamma radiations under normal incidence has been studied as a function of the dosemeter thickness to arrive at its optimum value.

Response to ^{137}Cs gamma radiation (samples irradiated under electronic equilibrium conditions) is a linear function of thickness upto ~ 100 $mg.cm^{-2}$ and becomes sublinear for larger thicknesses. Beta response for Nat.U and ^{90}Sr-^{90}Y (E_{max} = 2.2 Mev, range 1000 $mg.cm^{-2}$) is linear upto 200 $mg.cm^{-2}$, the maximum thickness studied. Response of bare dosemeters to ^{170}Tm (E_{max} = 0.97 Mev, Range = 370 $mg.cm^{-2}$) is linear upto 150 $mg.cm^{-2}$. For

^{240}Tl (E_{max} = 0.76 Mev, range 270 mg.cm^{-2}) irradiations of bare dosemeters, response is linear upto 50 mg.cm^{-2} only, beyond which it becomes sublinear.

Mica strips being used as antibuckling device in the TLD card having skived tape dosemeters, were examined for natural radioactivity, natural TL and gamma induced TL response. The mica being used was identified as natural muscovite, using X-ray diffraction techniques.

A single 80 mg.cm^{-2} thick tape dosemeter (51 mm x 17 mm) along with a mica strip replaces the presently used three 200 mg.cm^{-2} thick compressed disc dosemeters in the proposed individual monitoring system.

With the availability of readers modified for taking 80 mg/cm^2 thick tape-dosemeter card and having a reduced readout time of 30 sec as compared to 60 sec per dosemeter earlier), 4500 numbers of tape cards have been put into field for routine use. Earlier set of 1500 cards has been in field use for 2 1/2 years and has given satisfactory service and results. Another 10,000 tape cards are to be put into field use. Their quality assurance has been conducted.

3.3 DOSE COMPUTATION ALGORITHMS FOR THERMOLUMINESCENCE DOSIMETRY

A.V.Dere, K.L.Popli, J.S.Nagpal, D.K.Kapoor and P.H.Patel

Dose computations algorithms have been developed for interpretation of the TL readings obtained from three $CaSO_4$:Dy - Teflon dosemeters positioned in the presently used personnel monitoring TLD badge, in terms of wholebody - and skin dose. Algorithms are based on parametrization of the response to the various pure and mixed fields. It identifies the radiation field type, position of the badge during use (above or below the lead apron), making use of the appropriate correction factors.

An interface coupled to the TL Badge Reader stores the TL readings D1, D2 and D3 along with the relevant institution number, personnel number, for a set of 90 cards at a time. This data can be processed for determination of wholebody -, skin dose or operational quantities Hs(0.07) and Hp(10) using the dose algorithms either On-Line or Off-Line with the help of a PC. Dose report for the institution can be directly obtained in a hard copy form.

3.4 STUDIES WITH CR-39 SSNTD FOR PERSONNEL NEUTRON MONITORING

O.P.Massand, H.K.Kundu, M.P.Dhairyawan and P.K.Marathe

CR-39 SSNTD is suitable for personnel neutron monitoring due to its high sensitivity to protons and the studies have been

carried out on inherent background, etching conditions, sensitivity to beta gamma radiations and its energy response using various radioactive neutron sources. Based on these studies processing time for the CR-39 foils has been standardized. The foils can be easily stored over a period of two years without increase in background. The CR-39 SSNTD is insensitive to beta gamma radiations and has a flat neutron energy response. It has been introduced as a routine neutron personnel monitor and shall gradually replace Kodak NTA nuclear emulsion .

3.5 MEASUREMENT OF NEUTRON CONTAMINATION FROM LINEAR ACCELERATOR

P.K.Marathe, O.P.Massand, S.G.Sawant*, M.L.Bhutani*

Linear accelerators producing X-ray beams of 8MV and above produce some quantities of neutrons from the target, collimator, beam flattening filters, primary definer, secondary collimator jaws etc. CR-39 SSNTD neutron monitor was used for these measurements with Siemens Mevatron-12 medical accelerator at Tata Memorial Hospital. The neutron equivalent doses were measured at left, right, front, up and bottom positions of the accelerator. Scattered neutron equivalent doses were also measured in the treatment room. (* Radiological Physics Division)

3.6 QUALITY ASSURANCE STUDY IN BETA AND GAMMA DOSE EVALUATIONS USING FILM BADGES

G.S.Sharma, V.N.Patil, A.S.Pathak, R.R.Shukla, M.P.Sankaran, K.S.Shenoy, R.V.Dhond

A quality assurance programme was conducted for the evaluation of beta and gamma doses using the film badges. About 30 film badges exposed to various doses of beta, gamma and mixed beta and gamma radiations were evaluated by the normal procedure in vogue for the personnel monitoring service being carried out by this section using the film badges. In the case of only beta or gamma exposures the evaluated dose values were in good agreement (within $\pm$10% for gamma and within $\pm$15% for beta rays) with the actual exposure values. In the case of mixed beta and gamma exposures, while the gamma evaluation was in good agreement with the reference values, the beta doses evaluated were 3 to 5 times less than the actual exposures given. A further study is being carried out to study the causes of such gross under evaluation of beta doses from film badges in presence of gamma ray exposures.

3.7 STUDY TO EVOLVE A METHOD TO GENERATE X-RAY CALIBRATION DATA FROM THE GAMMA CALIBRATION DATA

Smt. D.Sarala Bai Amma, M.P. Sankaran, R.V. Dhond

Calibration of film packs to various energies of x-rays

involved in personnel monitoring is a time consuming process which has to be carried out for different consignments of Personal Monitoring Film packs at least twice in a year. Calibration to gamma radiation is comparatively easy. A study has been undertaken to find out an appropriate factor by which the dose read from the gamma calibration graph corresponding to optical Density produced by x-rays can be multiplied to arrive at the X-ray dose within acceptable accuracy. A preliminary study has been carried out to find this factor for the fast film in the Agfa Gevaert Film Packs currently being used for Personnel Monitoring in our country, exposed to 100 KVp X-rays for 3 different emulsions of film packs. Preliminary results are encouraging. The distribution of different values of these factors for different optical densities for the 3 different emulsions of film packs (a total of 639 values) shows that about 80% of these factors lie between 19 and 23 with an overall average value of 21.0. Some sample evaluation of X-ray doses read from the gamma calibration graphs and using above stated average value of factor as 21.0 shows that the evaluated X-ray dose values are in agreement with the dose values got from this direct X-ray calibrated data which is within $\pm$20%.

Above method of evaluating X-ray doses by referring gamma ray calibration curve is expected to make the requirement of laborious and time consuming X-ray calibration redundant.

3.8 EVALUATION OF INDU AND KODAK TYPE II PERSONNEL MONITORING FILMS

G.S.Sharma, V.N.Patil, A.S.Pathak, M.P.Sankaran, K.S.Shenoy, R.V.Dhond, H.K. Kundu, L.J.Puthran and R.L.Pandey.

INDU Films : The calibration of the films was carried out for Ra-226 gamma rays as well as 100 kVp X-rays to study their dosimetric characteristics and stored in a specially made box having 30°C and 90% relative humidity climatic condition. The films were developed after 2 and 4 weeks of their storage in the humidity box. The dosimetric characteristics of the INDU film revealed that they are about 6 to 7 times less sensitive compared to Agfa Gevaert films. The minimum detectable gamma dose is of the order of 0.35 mSv whereas for X-rays the minimum detectable dose was found out to be 0.05 mSv. INDU films were also found unsuitable during monsoon period in view of 35 to 40% latent image fading observed for 2 weeks storage in 20°C and 90% relative humidity. In conclusion it was found that the present type of INDU films could be used for routine monitoring only for x-rays and that too during dry season.

The fading studies repeated after sealing the individual film packs in aluminised mylar pouches, showed no latent image fading. M/s Hindustan Photo Film has been advised to make necessary improvements to increase the sensitivity of the films

and also to improve the quality of packing of the films by using aluminised mylar wrappers.

KODAK TYPE II FILM : Samples of the new Kodak type II film packs supplied to us were also evaluated for dosimetric and fading characteristics. The study revealed minimum detectable gamma ray dose of 0.25 mSv which is higher as compared with the value of 0.10 mSv in case of Agfa-Gevaert type films which are currently being used. Further the latent image fading exhibited by Kodak type II films is much higher i.e. more than 50% in two weeks. Therefore these films are not suitable for use during monsoon season. However, they could be used during dry season for monitoring of x-ray workers.

3.9 MISCELLANEOUS

An automatic film pack counting system, coupled to a PC and designed and developed by the Division of Remote Handling and Robotics (DRHR) of Bhabha Atomic Research Centre, is being continuously used for counting the films since February 1993, for the routine despatch of the film packs towards countrywide personnel monitoring. A stack of 150 films in a box is loaded onto the counter system. A drawer which moves underneath, picks up the films and delivers them at the other end from where these are manually collected and packed into envelopes for despatch. Our practical experience with the machine is satisfactory and the unit is expected to reduce manual labour.

Quality Assurance check of various TL monitoring stations is conducted twice a year to maintain uniform standard of accuracy and reproducibility.

Eight requests for complete dose record history of Indian scientists engaged in radiation work abroad were received and the pertinent dose records were provided.

Samples of TLD cards manufactured by ECIL were evaluated for their suitability for personnel monitoring. Dimensions of the cards and TLD discs, centering of discs on cards, background TL emission from discs, uniformity of response of discs to ionising radiation etc. were checked.

Commercially available lead-rubber aprons and lead-rubber gloves were tested for their lead-equivalence using TLD disc cards in collaboration with R.Ph. Division.

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B. RADIOLOGICAL ADVISORY SERVICES SECTION - P.Subrahmanyam

The Radiological Advisory Services Section consists of five groups viz. Industrial Advisory Services (A.V.Lakshmipathy), Medical Advisory Services (P.Sethulakshmi and S.P.Zaparde), Consumer Products Advisory Services (B.K.S.Murthy) and Transport Advisory Services (J.S.Bisht).

There are 350 industrial radiography institutions in the country with 821 Ir-192 sources, 81 Cobalt-60 sources, and 150 X-ray machines, four Tm-170 sources and one high energy accelerator, in use.

There are 115 teletherapy institutions having 183 teletherapy units including 15 accelerators, 90 brachytherapy institutions and 110 nuclear medicine centres. About 10,000 X-ray diagnostic machines are to be registered in the ensuing year.

There are 500 institutions using 3500 nucleonic gauges, 6 high intensity irradiators, 50 institutions using open isotopes for research, 125 institutions making consumer products like luminous dials, gas mantles and smoke detectors. There are 40 institutions using electron capture detectors, X-ray fluorescence analysers etc.

The transport advisory group advises on the transport of teletherapy sources, gamma irradiators, decayed sources despatched for disposal, bulk consignment of materials like magnesium diuranate, fuel from N.F.C. to reactors, consignments of thorium from IRE and irradiated nuclear fuel. In this work the Transport Advisory Group liases, with Director General of Civil Aviation, Port and Shipping Authorities and the Airlines.

All the groups in the Advisory Services have close interaction with the Atomic Energy Regulatory Board. The workload of the Advisory Services Section can be gauged from the work carried out in the last year.

1.	Inspections	: 120
2.	Plans approved	: 100
3.	Authorisations issued	: 1700
4.	Advice issued on safety related matters	: 4500
5.	Radiography cameras inspected	: 300
6.	Sources received for disposal	: 121

I. HIGHLIGHTS

1. Assistance has been provided in four incidents to industrial radiography institutions.

2. Apart from planning of X-ray and isotope radiography rooms a specialised plan for 12 MV linear accelerator to be

installed at L & T, Hazira has been developed.

3. Samples of watch dials obtained from watch manufacturing units were tested for activity estimation. Procedure was evolved to estimate the low activity of the order of a few kilo Bq of ^{3}H activated paint in each set of dial and hands. Activity was estimated to be 5 MBq in a dial and 2 MBq in a pair of hands.

4. Samples of gas mantles are being assessed for thorium activity. The method adopted at present is counting in gamma ray spectrometer and evaluating the activity. Activity of thorium per mantle varied from 1.5 kBq to 2.2 kBq.

5. Samples of some commercial brands of surge voltage protectors were studied for radioisotope identification and activity estimation. Procedures were evolved to study the samples and two brands were identified as containing ^{147}Pm and ^{3}H with activities of about 60 kBq and 5 kBq respectively. One brand was found to be free from radioactivity.

6. The fore sight and rear sight of self loading rifles are illuminated by ^{147}Pm activated radioluminous paint. Activity per gunsight and the exposure levels at various distances were measured. Based on the measurements, 1 mm thick plastic cover for the gun sight, while not in use, was recommended.

7. Pyrochlore and Ilmenite ores are used in the special alloy steel industries and these contain traces of thorium and uranium. Samples of starting material, slag and end products from these industries were counted for checking the presence of uranium and thorium in them. The highest content of thorium was found to be in the slag.

8. Internal monitoring of dial painters working with ^{3}H and ^{147}Pm activated radioluminous paints was continued. In the case of ^{3}H activated RLP workers, about 40 bioassay samples were analysed. For ^{147}Pm workers, bioassay samples of 10 workers were analysed. Based on the bioassay results, Committed Dose Equivalents for these workers was evaluated. For ^{147}Pm RLP workers, invivo counting was also done and the activity was found to be below detectable limit(less than 0.9 kBq).

9. Members of the group supervised the tests conducted on prototype units (Gammarid, SPEC-2, CPN/ MC-3 & AC-2) by manufacturers, for type approval of Industrial Radiography equipment and Nucleonic Gauges by Atomic Energy Regulatory Board.

10. Air-scattered and direct radiation dose measurement for 6 MV Betatron at Goa, for 4 MV linear accelerator at Itarsi and for 4 MV linear accelerator at Pune were done using different dosimeters.

11. Reports of periodic annual medical examinations of all industrial radiography workers in the country were obtained and are undergoing scrutiny by medical experts.

12. Compilation of User's Guide entitled 'Planning of Brachytherapy Installation' has been completed. The guide contains general information on current regulations for establishment and operation of brachytherapy installations. The guide will be helpful to users intending to establish a brachytherapy department.

13. The USER'S GUIDE entitled 'Planning of Teletherapy Installations' has been revised. This guide is useful for users intending to establish teletherapy facility.

14. Issues oi Newsletters have been brought out. The NEWSLETTER provides information regarding unusual radiation incidents, follow up and remedial action and other general informations and notifications received from AERB from time to time. The Newsletter has been sent to all radiation users in the country.

15. The Working Group II for Teletherapy Safety Guide has been formed to help the Advisory Committee constituted by Chairman, AERB in the preparation of the Guide. The purpose of the Guide is to provide detailed information regarding each clause mentioned in the AERB Safety Code SC/MED-1 entitled " Telegamma Therapy Equipment and installations". Smt. P.Sethulakshmi and Shri G. Janakiraman of Advisory Services are members of the above Committee. The Guide is under completion.

16. A general application form for disposal of radioactive wastes in small institutions using radioisotopes has been prepared by a committee constituted by AERB in which Smt.P.Sethulakshmi, Dr.B.K.S.Murthy and Shri V.K.Kathuria are members. The Committee has met periodically and a general format has been evolved.

17. Considering the hazards associated with the use of radium it was decided to withdraw radium from all the hospitals in India. During the year 736 mg of radium from two institutions has been collected and disposed off in BARC as radioactive waste. Radium has been collected from 59 institutions so far out of 65 institutions. Process of collection of Radium sources from the remaining 6 institutions.

18. IAEA Co-ordinated Research Programme (CRP):- The transport advisory group is associated with an IAEA co-ordinated research program on "The Development of Probabilistic Safety Assessment (PSA) Techniques Related to the Safe Transport of Radioactive Material" for the risk assessment to transport workers,cargo handlers and members of public due to transportation of radioactive material. The evaluation of risk is based on a computer code RADTRAN IV which is supplied by IAEA to all the participating countries in the programme. The project is now in the final stage and after the final meeting, the code will be made available to any country from IAEA desirous of assessing risk due to transport of radioactive material in their studies.The code will be supported by appropriate documentation.The final code will be published by IAEA, Vienna as an international computer code (INTERTRAN-2) as a reference assessment tool for both incident-free and accident conditions.

19. A study was carried out on the dose received by cargo handlers at Bombay Airport.It was carried out only on those packages which originated from BRIT,Bombay and were despatched to various destinations from Bombay Airport on domestic flights. Personnel Monitoring TLD badges were issued to those persons who were involved in some way or other in cargo handling operations. The same set of badges were given to persons working in different shifts. The basic purpose was to assess collective dose. This study was carried out with a view to reclassify the transport workers based on new ICRP-60 dose limits and to study the impact of new ICRP recommendations on transport regulations. Since the studies showed that the collective dose received by transport workers in this limited segment was quite low, it may not be necessary to change the transport regulations substantially.

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