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Radiation Safety and Monitoring Section

Division of Radiation, Transport and Waste Safety

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Executive Summary

The Radiation Safety Regulations of the International Atomic Energy Agency (IAEA) require the Radiation Safety Technical Services Officer to submit an Annual Report to the Radiation Safety and Nuclear Security Regulator on doses to occupationally exposed workers (OEWs). The report provides a general summary of radiation safety technical service activities in the IAEA, covering activities for the Individual Monitoring Service Group (IMSG) and the Operational Radiation Monitoring Service Group (ORMSG) established as part of the IAEA Testing Laboratory for Radiation Measurement, Monitoring and Protection in the Radiation Safety Technical Services Unit (RSTSU). The laboratory is accredited under the quality standard ISO/IEC 17025:2005, which defines management and technical requirements in order to demonstrate technical competence of a laboratory and the validity of the results generated. In accordance with the requirements of this standard, the effectiveness of the laboratory's management system and technical operations are monitored continuously.

Individual Monitoring Service Group

In the reporting period, monitoring services for external and/or internal exposure to ionizing radiation were provided to 2367 individuals registered as OEWs. This included 746 IAEA staff members, 1106 non-staff members[1] within the Technical Cooperation (TC) programme, and 515 non-staff members outside the TC programme. The average and maximum total effective dose as well as the number of OEWs monitored and measurements conducted is summarized for each category in the table below.

TOTAL EFFECTIVE DOSE TO STAFF MEMBERS AND NON-STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
Staff members	746	16804	0.37	9.54
Non-staff members	1621	2293	0.07	2.21
Total	2367	19097	0.18	9.54

In the same period, 91 staff members and 380 non-staff members were provided a finger-ring dosimeter. The average and maximum equivalent dose to the extremities as well as the number of OEWs monitored and measurements conducted is summarized for each category in the Table below.

EQUIVALENT DOSE TO EXTREMITIES OF STAFF MEMBERS AND NON-STAFF MEMBERS IN 2016.

Division/Section	Number of monitored OEWs	Number of measurements	Average equivalent dose (mSv)	Maximum equivalent dose (mSv)
Staff members	91	728	0.75	16.92
Non-staff members	380	348	0.12	8.62
Total	471	1076	0.26	16.92

A total of 239 whole-body and 63 finger-ring dosimeters issued for TC activities were not returned to the IMSG in 2016. As a consequence, no dose assessments could be done for those OEWs.

[1] Non-staff members are individuals working in activities under IAEA control or supervision such as external experts, trainees, fellows, scientific visitors and consultants.

Distribution and loan services for personal protective equipment and radiation monitoring instruments were provided as requested through the Radiation Monitoring and Protection Service (RMPS) Desk by IAEA staff members. The demand for instrument loan services continued to increase significantly in the reporting period, amounting to an overall increase in items provided of 44% compared with the previous year, while the number of personal protective equipment distributed to staff members maintained the high level of 2015. In December 2016, agreement was reached that as of 1 January 2017 distribution of personal protective equipment would be administered by the Department of Safeguards Equipment Service Desk.

Operational Radiation Monitoring Service Group

The ORMSG provides services at the IAEA Seibersdorf premises for the Departments of Nuclear Sciences and Applications (NA) and Safeguards (SG). In 2016, the ORMSG performed special and emergency radiation monitoring in 24 designated areas of the former SGAS Nuclear Material Laboratory (NML), also known as the Safeguards Analytical Laboratory (SAL). Routine, special and emergency radiation monitoring was done in the new NML, including 60 rooms in controlled areas and 10 rooms in supervised areas. Thirteen joint radiation safety documents were established in 2016. Routine, special, and emergency radiation monitoring was also performed in NA laboratories, including 13 rooms in controlled areas and 9 rooms in supervised areas.

Assistance with the radiation monitoring programme was provided for the SG Equipment Radiation Monitoring Laboratory (ERML) in the Vienna International Centre. For this laboratory, ORMSG also provides quality management system coverage under the ISO/IEC 17025:2005 accreditation of the Testing Laboratory.

The ORMSG and ERML performed 48103 workplace monitoring measurements in SAL, NML, NA and ERML laboratories, an increase of 1%. Calibration services were provided for 372 radiation monitoring instruments including portable and fixed dose rate and surface contamination meters, a decrease of 9%.

More than 300 staff members were provided training in 2016 by IMSG and ORMSG.

Conclusions and Recommendations

Directors in Charge and Radiation Protection Officers (RPOs) can use this report to assist in assessing the effectiveness of their radiation safety programmes. Dose trends and details are provided for this use. The report reflects the trend of the past five years showing steadily increasing demands for monitoring services. RPOs are requested to review their programmes to ensure monitoring meets their needs and to request additional services from the RSTSU as far in advance as possible. Programme changes should be discussed with enough notice for RSTSU to request resources during biennial budget discussions. Should such programmatic changes not be anticipated during the development of the budget, RSTSU may require the requesting organizational group to transfer funds during the financial year.

1 Introduction and Dose Limits

The International Atomic Energy Agency (IAEA) has the statutory responsibility to apply its safety standards for protection of health to its own operations. According to the IAEA Radiation Safety Regulations enforced on 1 November 2007 (SEC/DIR/32 and Part X, IAEA Administrative Manual), radiation monitoring of staff and the workplace is undertaken under the responsibility of the respective Directors in Charge and supported by the Radiation Safety Technical Services Officer (RSTSO). The RSTSO is the Head of the Radiation Safety and Monitoring Section (RSM) within the Division of Radiation, Transport and Waste Safety (NSRW). The RSTSO is responsible for providing, or arranging for the provision of, the technical support services required by the Directors in Charge and submitting an Annual Report to the Radiation Safety and Nuclear Security Regulator on doses to occupationally exposed workers (OEWs). This report covers the period 1 January to 31 December 2016 and summarizes activities conducted by the Individual Monitoring Service Group (IMSG) and the Operational Radiation Monitoring Service Group (ORMSG) of the Radiation Safety Technical Services Unit (RSTSU).

According to the IAEA Radiation Safety Regulations, the occupational exposure of any worker shall be controlled so that the following limits are not exceeded:

(a) an effective dose of 20 mSv per year averaged over five consecutive years (100 mSv in 5years) and of 50 mSv in any single year;

(b) an equivalent dose to the lens of the eye of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years) and of 50 mSv in any single year;

(c) an equivalent dose to the extremities (hands and feet) or to the skin (average dose over 1 cm^2 in the most highly irradiated area of the skin) of 500 mSv in a year.

The effective dose limits specified in this schedule apply to the sum of the relevant doses from external exposure in the specified period and the relevant committed doses from intakes in the same period; the period for calculating the committed dose shall normally be 50 years for intakes by adults. For the purpose of demonstrating compliance with the dose limits, the sum of the personal dose equivalent from external exposure to strongly penetrating radiation in the specified period and the committed effective dose from intakes of radioactive substances in the same period, i.e. the total effective dose, shall be taken into account, using the methods given in *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, General Safety Requirements Part 3*.

2 Quality Assurance and Control

The IAEA Testing Laboratory for Radiation Measurement, Monitoring and Protection established in NSRW/RSM is accredited in accordance with the international standard ISO/IEC 17025:2005 – *General Requirements for the Competence of Testing and Calibration Laboratories.* This standard defines management and technical requirements that testing and calibration laboratories must meet to demonstrate that they are operating under a quality management system, are technically competent and able to generate technically valid results.

In accordance with the requirements of this standard, the effectiveness of the laboratory's management system and technical operations are monitored continuously through external and internal quality audits and management reviews. Quality objectives are used by the management and staff members of the testing laboratory to guide the continuous improvement of the quality management system.

In the reporting period, the laboratory successfully completed its reaccreditation audit conducted by Akkreditierung Austria, the Austrian National Accreditation Body based in the Federal Ministry of Science, Research and Economy.

The performance of the monitoring methods is assessed by regular participation in proficiency testing exercises. In the reporting period, the Testing Laboratory participated in the

- European Radiation Dosimetry Group (EURADOS) interlaboratory comparison 2016 for whole-body photon dosimeters,
- German Federal Office for Radiation Protection (BfS) interlaboratory comparison 2016 for alpha and beta emitters in urine,
- Association for the Promotion of Quality Control in Radiotoxicological Analysis (PROCORAD) interlaboratory comparison 2016 for alpha, beta and gamma emitters in urine and faeces,
- Global Health Security Initiative (GHSI) emergency radionuclide bioassay exercise 2016 for alpha, beta and gamma emitters in urine,
- Lawrence Livermore National Laboratory (LLNL)/EURADOS interlaboratory comparison 2016 for in-vivo thyroid measurements,
- German Federal Office for Radiation Protection (BfS) interlaboratory comparison 2016 for in-vivo whole-body and thyroid measurements.

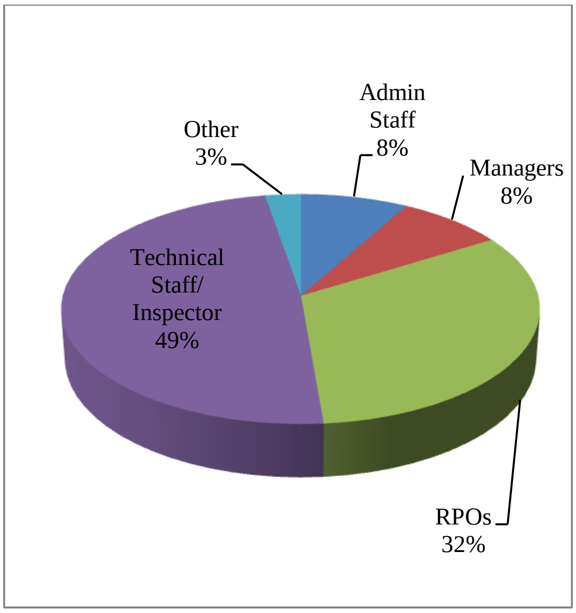
For several methods, the laboratory ranked among the best performing participants. In all cases, the acceptance criteria for the accuracy of test results defined in international standards were fulfilled.

2.1 CUSTOMER SATISFACTION SURVEY

The Testing Laboratory conducted an online customer survey in September 2016 in order to collect customer feedback on the services provided and to identify areas of improvement. This was the first time the Testing Laboratory conducted such a comprehensive online survey.

The survey was sent to a total number of 84 customers selected based on their frequent use of the services. This included managers, technical staff/inspectors, RPOs, administrative assistants and others. Thirty-seven customers responded to the survey for a response rate of 32%.

The figure below shows the distribution of the respondents. Forty-nine percent of the respondents are Technical Staff/Inspectors and 65% of the respondents work at Safeguard Department.



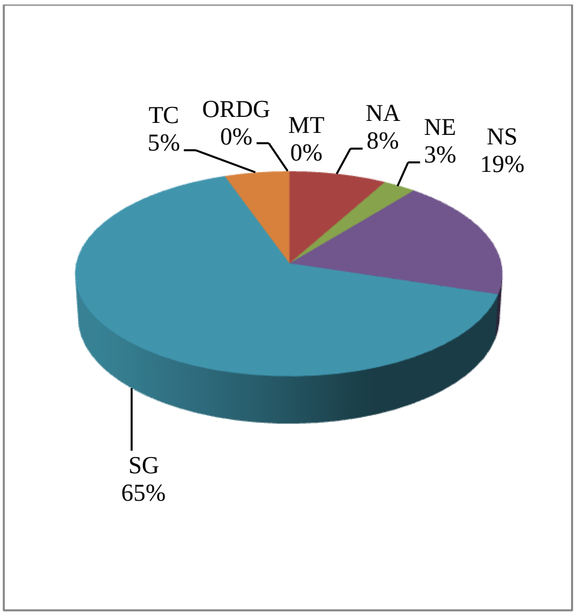


FIGURE 2.1: DISTRIBUTION OF CUSTOMER SURVEY RESPONDENTS

As shown in Table 2.1, respondents were overall satisfied with the services. Some areas may be considered for a more in-depth review. As part of the continual improvement initiatives, the Testing Laboratory will continue to conduct customer surveys in order to assess customer needs and expectations. A customer feedback link is also available as an option on the RMPS desk home page.

TABLE 2.1 SUMMARY OF RESULTS OF 2016 CUSTOMER SURVEY

	Overall satisfied (%)	**Overall unsatisfied (%)**
External monitoring (IMSG)		
Quality of the service	90	6
Availability of staff	96	0
Internal monitoring (IMSG)		
Quality of urinalysis	85	7
Quality of whole-body counting	97	0
Availability of staff	96	4
Measurement reports	66	28
Workplace monitoring (ORMSG)		
Quality of the service	74	16
Availability of staff	84	0
Measurement reports	82	6

Note: results do not add up to 100% because respondents who marked “neutral” are not reported here.

3 Assessment of Occupational Exposure

In the reporting period, 3090 individuals were registered as OEWs. Of those, 2367 workers received monitoring services for external and/or internal exposure to ionizing radiation, comprising 746 staff and 1621 non-staff members. The difference in number between registered and monitored OEWs is related to ad-hoc monitored staff members who did not request services, staff members who separated from the IAEA without cancellation of individual monitoring, and cancelled or postponed fellowships, missions and training courses. The trends in the number of OEWs for the IAEA, staff members from the Department of Safeguards (SG) and non-staff members within the Technical Cooperation (TC) programme since 1996 are illustrated in Figure 3.1. TC and SG are presented separately due to their relatively higher numbers of usage. The rest of the total is distributed comparatively evenly amongst the Departments of Nuclear Sciences and Applications (NA), Nuclear Safety and Security (NS) and Nuclear Energy (NE). The figure shows that the number of OEWs in 2016 was slightly lower than in 2015.

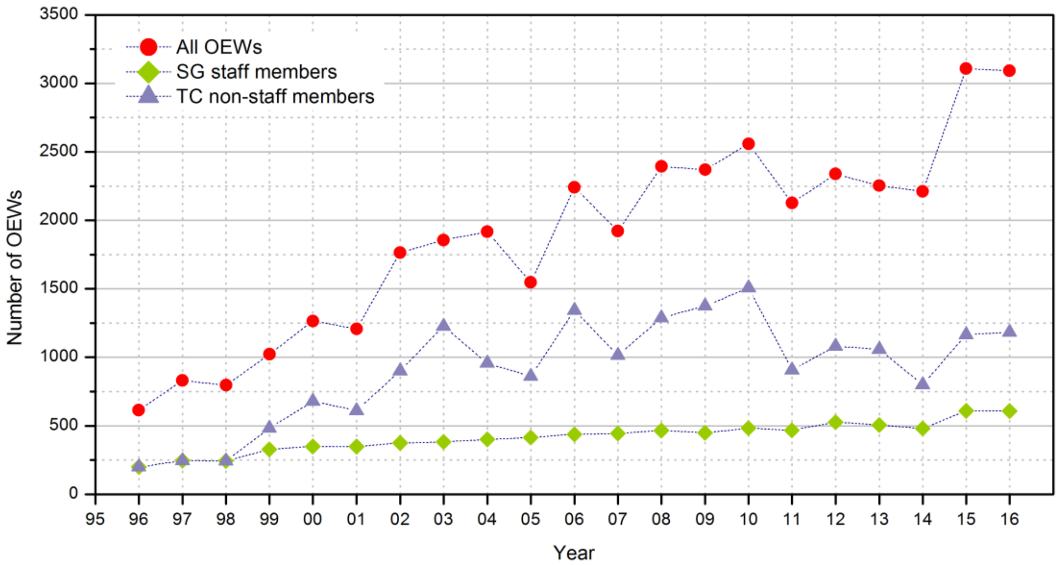


FIGURE 3.1: TRENDS IN THE NUMBER OF OEWS FOR THE IAEA, TC AND SG (1996-2016).

Individual monitoring services include thermoluminescence dosimetry (TLD) of the whole body and the extremities, active personal dosimetry (APD), body activity measurements (whole body, lungs), radiobioassay analysis of excreta (urine, faeces, saliva) and dose assessment from intakes of radionuclides using models recommended by the International Commission on Radiological Protection (ICRP). With dosimetry systems having become available, which meet international standards including measurement traceability to the International System of Units (SI), an implementation plan was developed for monitoring of exposure to the lens of the eye. As a consequence of the lacking demand, equivalent doses to the skin were not assessed. Technical information on the services is accessible worldwide through http://ns-files.iaea.org/files/imsg-customer-info.pdf. The customer demand for individual monitoring services is increasing steadily since 1996, as illustrated in Figure 3.2 and Table 3.1, respectively. The data reported for each method include quality assurance and control measurements. In case of external dosimetry, background, emergency and stand-by dosimeters are considered as well. In 19 cases, high-priority whole-body counting and urine analysis was carried out for urgent requests.

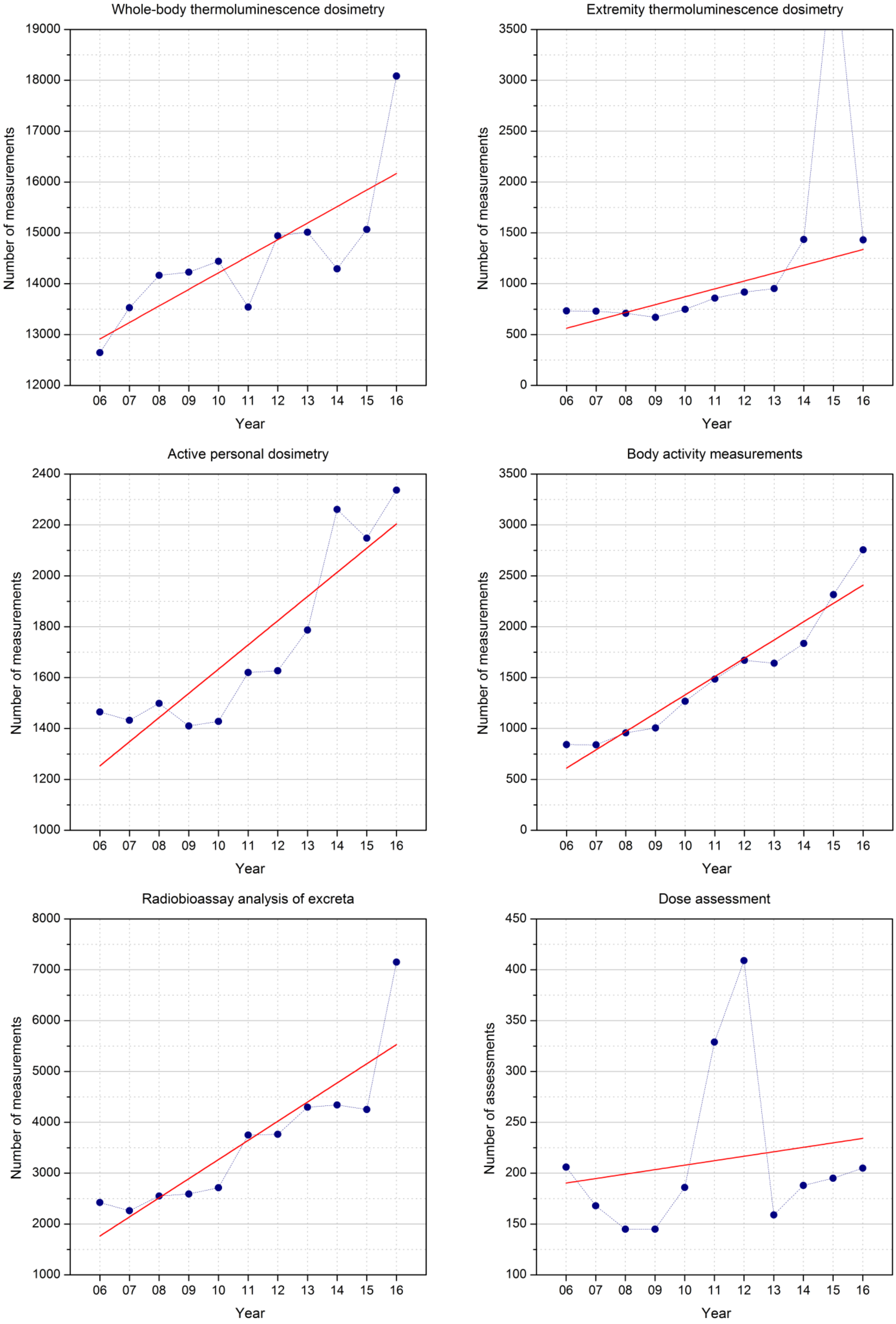


FIGURE 3.2: TRENDS IN THE NUMBER OF SERVICES PROVIDED BY THE INDIVIDUAL MONITORING SERVICE GROUP (2006-2016).

TABLE 3.1: TRENDS IN NUMBER OF ASSESSMENTS USING DIFFERENT METHODS (2012-2016).

Method	Number of assessments				
	2012	2013	2014	2015	2016
Whole-body thermoluminescence dosimetry	14934	15013	14294	15068	18084
Extremity thermoluminescence dosimetry	917	952	1435	4312	1432
Active personal dosimetry	1627	1787	2261	2148	2337
Body activity measurements (whole body, lungs)	1670	1641	1836	2315	2756
Radiobioassay analysis of excreta (urine, faeces, saliva)	3765	4297	4342	4252	7153
Dose assessment	409	159	188	195	205
Total	23322	23849	24356	28290	31967

3.1 Whole-Body Doses

In the reporting period, 1053 staff members of the IAEA were registered as OEWs, of which 746 individuals had received monitoring services, representing an increase of less than 1% compared with the previous year. Of those, 602 workers or 81% were monitored continuously. The distribution of total effective doses, comprising whole-body exposures to external and internal sources of ionizing radiation for compliance with regulatory limits, is illustrated in Figure 3.3. Equivalent doses to the extremities are discussed in Chapter 3.2.

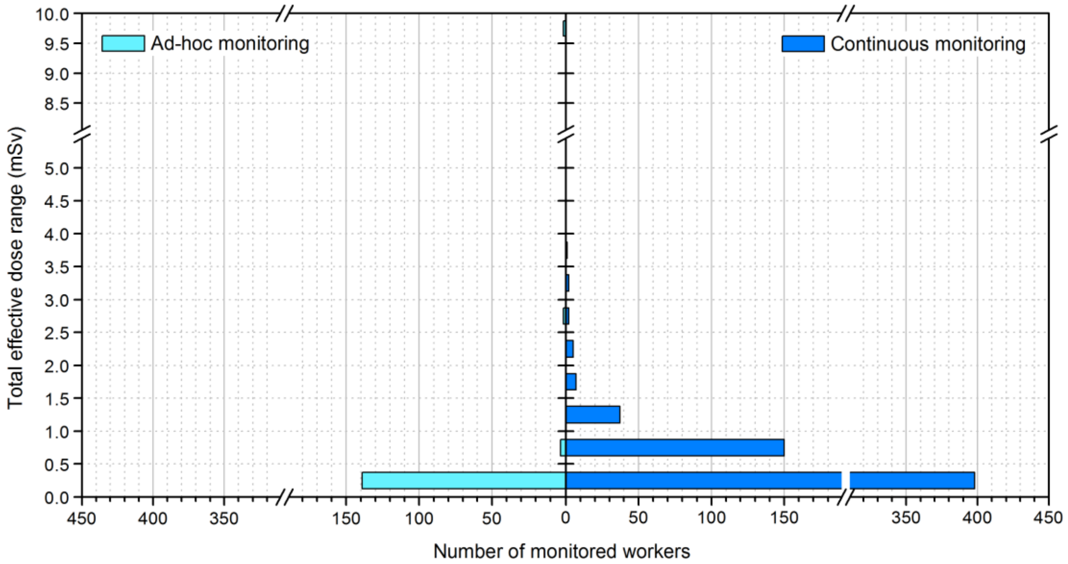


FIGURE 3.3: DISTRIBUTION OF TOTAL EFFECTIVE DOSE MEASURED FOR CONTINUOUSLY AND AD-HOC MONITORED IAEA STAFF MEMBERS IN 2016.

The average total effective dose was 0.37 mSv, with a maximum of 9.54 mSv. Ninety-three percent of monitored OEWs received a total effective dose of less than 1 mSv. Table 3.2 compares the monitoring results to the data from the previous five years. Since 2012, the average total effective dose received by IAEA staff members remained stable at around 0.50 mSv.

Some charts presented in this report indicate the value of optimizing individual monitoring based on the potential for exposure. For OEWs who do not have the potential for routine exposures, monitoring should be requested as needed through the RMPS Desk. RPOs are requested to assess their programmes to optimize use of services. RSTSU assists in these assessments upon request.

TABLE 3.2: DISTRIBUTION OF TOTAL EFFECTIVE DOSE TO IAEA STAFF MEMBERS IN INDIVIDUAL YEARS (2012-2016).

	2012		2013		2014	
Range of total effective dose (mSv)	Number of monitored workers	Avg. total effective dose (mSv)	Number of monitored workers	Avg. total effective dose (mSv)	Number of monitored workers	Avg. total effective dose (mSv)
< 1.0	689	0.25	644	0.32	642	0.37
1.01−2.0	58	1.32	77	1.27	67	1.24
2.01−3.0	27	2.29	17	2.38	12	2.46
3.01−4.0	10	3.57	1	3.11	4	3.76
4.01−5.0	5	4.50	4	4.33	0	—
5.01−6.0	1	5.84	2	5.51	0	—
6.01−7.0	4	6.39	2	6.35	0	—
7.01−8.0	0	—	0	—	0	—
8.01−9.0	0	—	0	—	0	—
9.01−10.0	1	9.33	0	—	0	—
> 10.01	0	—	0	—	0	—
Total	795	0.52	747	0.51	725	0.50

	2015		2016	
Range of total effective dose (mSv)	Number of monitored workers	Avg. total effective dose (mSv)	Number of monitored workers	Avg. total effective dose (mSv)
< 1.0	677	0.33	691	0.27
1.01−2.0	53	1.22	44	1.25
2.01−3.0	9	2.30	7	2.44
3.01−4.0	1	3.40	3	3.46
4.01−5.0	2	4.69	0	—
5.01−6.0	1	5.44	0	—
6.01−7.0	0	—	0	—
7.01−8.0	0	—	0	—
8.01−9.0	0	—	0	—
9.01−10.0	0	—	1	9.54
> 10.0	0	—	0	—
Total	743	0.51	746	0.37

3.1.1 Department of Safeguards

In the reporting period, 607 staff members of the Department of Safeguards were registered as OEWs, of which 493 individuals had received monitoring services, representing a decrease of 1% compared with the previous year. Of those, 449 workers or 91% were monitored continuously. The distribution of total effective dose received by SG staff members in 2016 is illustrated in Figure 3.4. The monitoring results are further detailed according to organizational entity in Tables 3.3−3.9. The average total effective dose was 0.45 mSv, with a maximum of 3.52 mSv. Ninety percent of monitored OEWs received a total effective dose of less than 1 mSv.

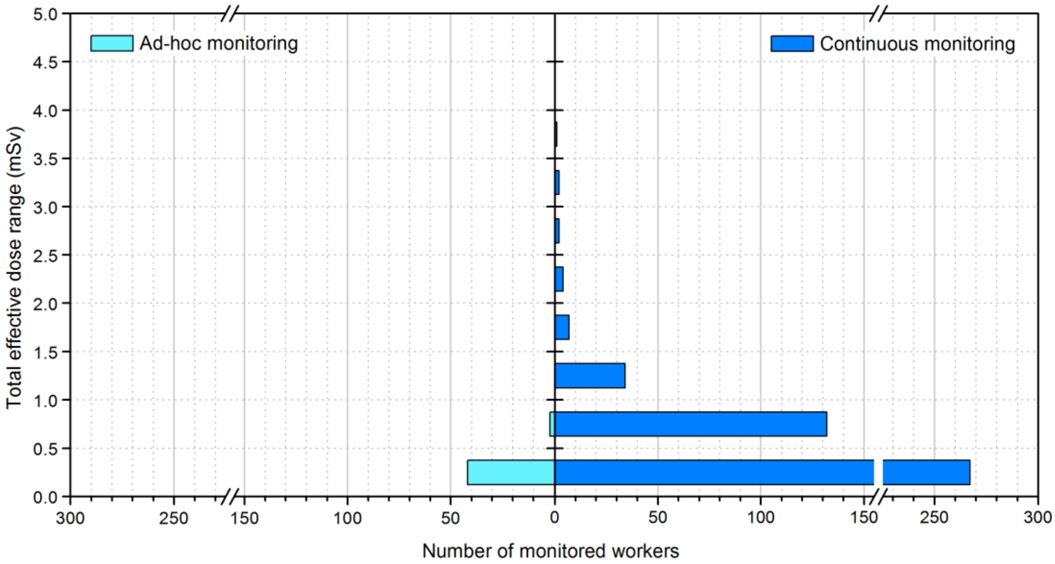


FIGURE 3.4: DISTRIBUTION OF TOTAL EFFECTIVE DOSE RECEIVED BY CONTINUOUSLY AND AD-HOC MONITORED SG STAFF MEMBERS IN 2016.

TABLE 3.3: INDIVIDUAL MONITORING FOR SG/DIVISION OF OPERATIONS A STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
SGOA	1	5	0.36	0.36
SGOA/OA1	19	626	0.56	1.29
SGOA/OA2	20	658	0.70	1.35
SGOA/OA3	15	526	0.54	1.02
SGOA/OAC	6	186	0.26	0.51
SGOA/OAT	15	367	0.46	1.22
Total	76	2368	0.55	1.35

TABLE 3.4: INDIVIDUAL MONITORING FOR SG/DIVISION OF OPERATIONS B STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
SGOB	1	34	0.19	0.19
SGOB/OB1	19	583	0.79	3.49
SGOB/OB2	0	0	—	—
SGOB/OB3	22	709	0.87	3.36
SGOB/OB4	24	741	0.93	2.84
SGOB/OBC	7	199	0.22	0.57
Total	73	2266	0.80	3.49

TABLE 3.5: INDIVIDUAL MONITORING FOR SG/DIVISION OF OPERATIONS C STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
SGOC	1	34	0.42	0.42
SGOC/OC1	17	572	0.57	1.27
SGOC/OC2	20	686	0.64	1.14
SGOC/OC3	18	607	0.62	1.11
SGOC/OC4	19	606	0.43	1.09
SGOC/OCC	9	284	0.13	0.49
Total	84	2789	0.52	1.27

TABLE 3.6: INDIVIDUAL MONITORING FOR SG/DIVISION OF TECHNICAL AND SCIENTIFIC SERVICES STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
SGTS/TND	24	697	0.51	3.52
SGTS/TSI	18	487	0.27	1.57
SGTS/TUS	28	863	0.44	2.15
SGTS/TVL	12	409	0.13	0.42
Total	82	2456	0.38	3.52

TABLE 3.7: INDIVIDUAL MONITORING FOR SG/DIVISION OF CONCEPTS AND PLANNING STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
SGCP	5	161	0.33	0.39
SGCP/CCA	12	108	< 0.05	0.19
SGCP/CPD	4	45	< 0.05	0.10
SGCP/CTR	11	295	0.39	1.35
Total	32	609	0.20	1.35

TABLE 3.8: INDIVIDUAL MONITORING FOR SG/DIVISION OF INFORMATION MANAGEMENT STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
SGIM	1	34	2.70	2.70
SGIM/IFC	10	274	0.25	0.88
SGIM/ISD	4	81	< 0.05	0.14
SGIM/ISF	8	23	0.16	0.81
SGIM/ISI	3	10	0.06	0.12
Total	26	422	0.26	2.70

TABLE 3.9: INDIVIDUAL MONITORING FOR SG/OFFICE OF THE DEPUTY DIRECTOR GENERAL STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
SG/DDGO	1	6	0.91	0.91
SG/CCS	2	36	0.18	0.35
SG/SPQ	3	90	0.08	0.23
SG/SPR	0	0	—	—
SGAS	7	155	0.10	0.22
SGAS/CSS	13	408	0.30	0.75
SGAS/ESL	14	368	0.10	0.22
SGAS/NML	25	736	0.23	0.92
SGAS/PMG	2	44	0.14	0.15
SGIS	2	32	< 0.05	0.06
SGVI	2	63	< 0.05	0.07
SGVI/OVI1	23	656	0.34	1.08
SGVI/OVI2	20	669	0.49	0.97
SGVI/OVIC	6	197	0.15	0.31
Total	120	3460	0.27	1.08

3.1.2 Department of Nuclear Sciences and Applications

In the reporting period, 152 staff members of the Department of Nuclear Sciences and Applications were registered as OEWs, of which 122 individuals had received monitoring services, representing an increase of 15% compared with the previous year. Of those, 113 workers or 93% were monitored continuously. The Radiation Protection Officer optimized the individual monitoring programme during the year by changing the frequency of external exposure assessment of NA staff members, with the exception of NAHU/DMRP, from monthly to quarterly. In the optimization process, consideration was given to the type of work being performed, the anticipated external exposure associated with it and the recording level of the dosimetry system. The distribution of total effective dose received by NA staff members in 2016 is illustrated in Figure 3.5. The monitoring results are further detailed according to organizational entity in Table 3.10. The average total effective dose was 0.24 mSv, with a maximum of 1.45 mSv. Ninety-nine percent of monitored OEWs received a total effective dose of less than 1 mSv.

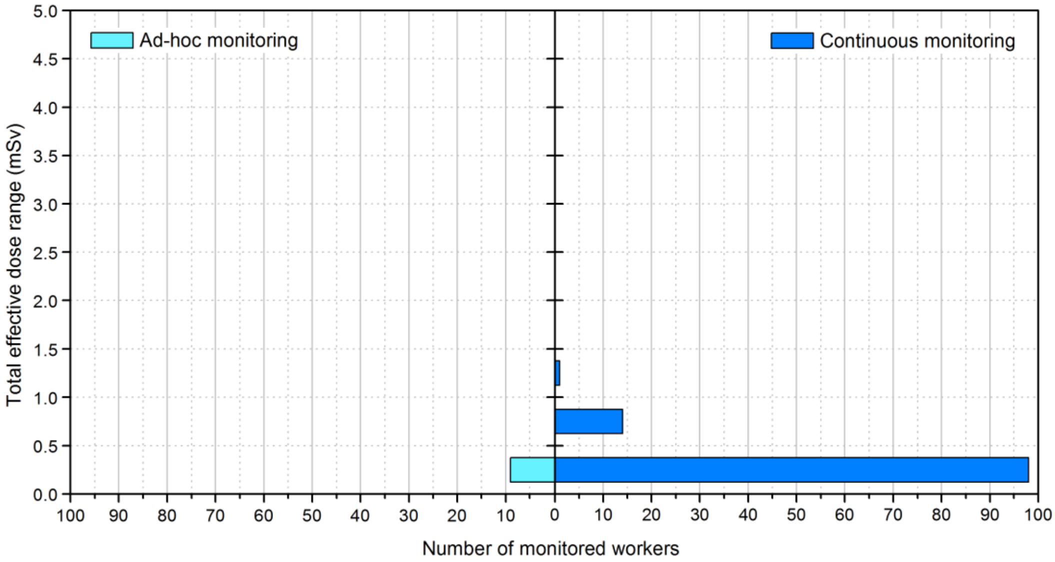


FIGURE 3.5: DISTRIBUTION OF TOTAL EFFECTIVE DOSE RECEIVED BY CONTINUOUSLY AND AD-HOC MONITORED NA STAFF MEMBERS IN 2016.

TABLE 3.10: INDIVIDUAL MONITORING FOR NA STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
NA/DDGO	2	16	0.06	0.11
NAEL/MOC	31	135	0.05	0.72
NAEL/TEL	8	96	0.28	0.46
NAFA	46	287	0.30	0.54
NAHU	21	250	0.35	0.83
NAPC	14	146	0.31	1.45
Total	122	930	0.24	1.45

3.1.3 Department of Nuclear Safety and Security

In the reporting period, 205 staff members of the Department of Nuclear Safety and Security (NS) were registered as OEWs, of which 85 individuals received monitoring services, representing a decrease of 11% compared with the previous year. Of those, 29 workers or 34% were monitored continuously. The distribution of total effective dose received by NS staff members in 2016 is illustrated in Figure 3.6. The monitoring results are further detailed according to organizational entity in Table 3.11. The average total effective dose was 0.16 mSv, with a maximum of 2.94 mSv. Ninety-six percent of monitored OEWs received a total effective dose of less than 1 mSv.

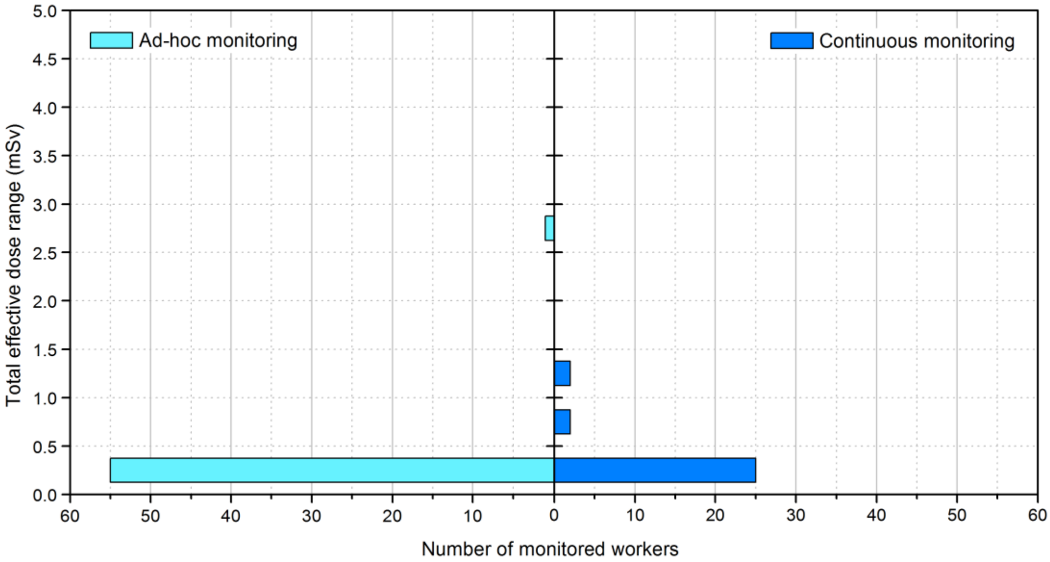


FIGURE 3.6: DISTRIBUTION OF TOTAL EFFECTIVE DOSE RECEIVED BY CONTINUOUSLY AND AD-HOC MONITORED NS STAFF MEMBERS IN 2016.

TABLE 3.11: INDIVIDUAL MONITORING FOR NS STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
NS/DDGO	1	1	< 0.05	< 0.05
NS/IEC	15	73	0.20	2.94
NS/SSCS	0	0	—	—
NSNI	25	468	0.25	1.29
NSNS	14	127	0.10	0.42
NSOC	1	7	0.13	0.13
NSRW	29	424	0.11	0.48
Total	85	1100	0.16	2.94

3.1.4 Other Departments and Offices

In the reporting period, 99 staff members of the Departments of Management (MT), Nuclear Energy and Technical Cooperation as well as the Offices Reporting to the Director General (ORDG) were registered as OEWs, of which 46 had received monitoring services, representing an increase of 7% compared with the previous year. Of those, 11 workers or 24% were monitored continuously. The distribution of total effective dose received by MT, NE, TC and ORDG staff members in 2016 is illustrated in Figure 3.7. The monitoring results are further detailed according to organizational entity in Table 3.12. The average total effective dose was 0.37 mSv, with a maximum of 9.54 mSv. Ninety-six percent of monitored OEWs received a total effective dose of less than 1 mSv.

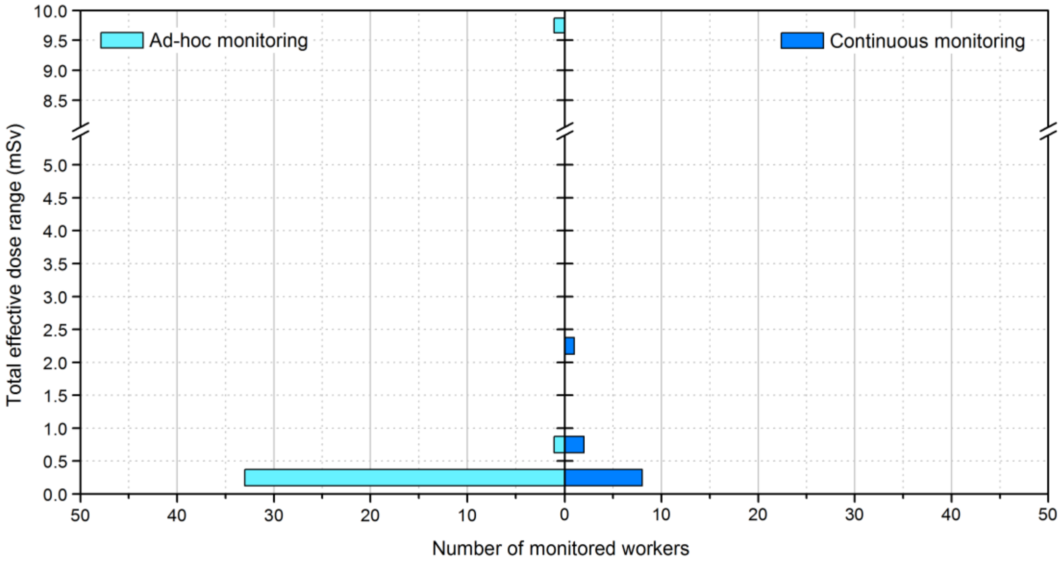


FIGURE 3.7: DISTRIBUTION OF TOTAL EFFECTIVE DOSE RECEIVED BY CONTINUOUSLY AND AD-HOC MONITORED MT, NE, ORDG AND TC STAFF MEMBERS IN 2016.

TABLE 3.12: INDIVIDUAL MONITORING FOR MT, NE, ORDG AND TC STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
MTGS	10	260	0.24	0.67
NEFW	15	91	0.85	9.54
NENP	0	0	—	—
OIOS	9	32	0.14	0.43
OPIC	4	9	0.09	0.15
TCAF	5	8	0.05	0.16
TCAP	2	3	< 0.05	0.06
TCEU	1	1	< 0.05	< 0.05
TCLAC	0	0	—	—
Total	46	404	0.37	9.54

3.1.5 Non-Staff Members

In the reporting period, 2037 non-staff members were registered as OEWs, of which 1621 individuals had received monitoring services, representing a decrease of 4% compared with the previous year. The distribution of total effective dose received by non-staff members in 2016 is illustrated in Figure 3.8 and further detailed according to organizational entity in Tables 3.13−3.14. The average total effective dose amounted to 0.07 mSv, with a maximum of 2.21 mSv. Ninety-nine percent of non-staff members received a total effective dose of less than 1 mSv.

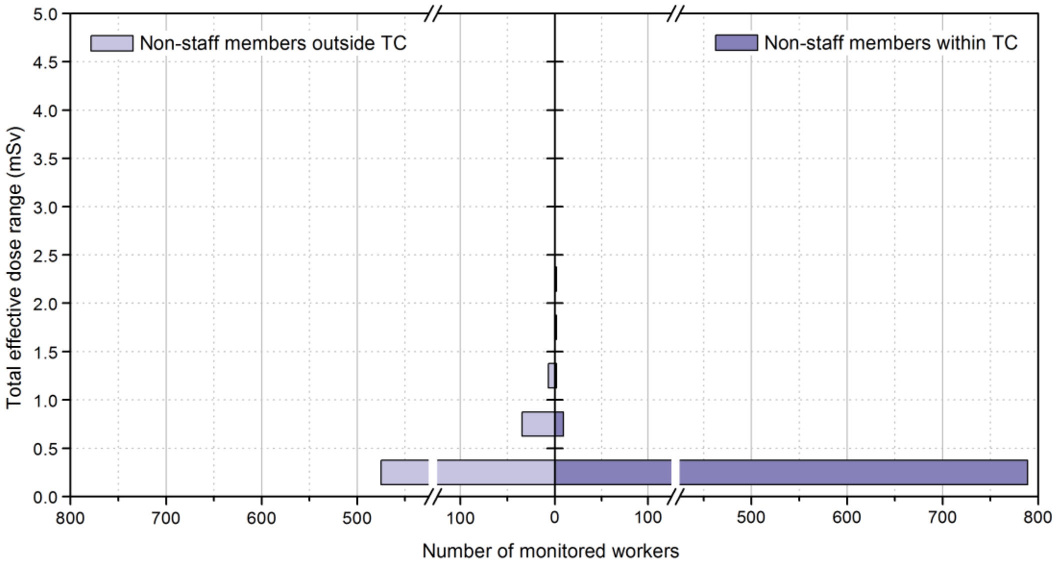


FIGURE 3.8: DISTRIBUTION OF TOTAL EFFECTIVE DOSE RECEIVED BY NON-STAFF MEMBERS IN 2016.

TABLE 3.13: INDIVIDUAL MONITORING FOR NON-STAFF MEMBERS INVOLVED IN TC ACTIVITIES IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
TCAF	358	323	< 0.05	0.27
TCAP	394	452	0.05	2.21
TCEU	197	291	0.01	0.63
TCLAC	157	217	0.12	1.92
Total	1106	1283	0.06	2.21

TABLE 3.14: INDIVIDUAL MONITORING FOR NON-STAFF MEMBERS OUTSIDE THE TC PROGRAMME IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
MTGS	36	323	0.66	1.09
NA/DDGO	10	10	< 0.05	0.07
NAEL/MOC	27	82	0.05	0.56
NAFA	3	23	0.13	0.25
NAHU	3	5	0.05	0.10
NAPC	13	13	0.05	0.10
NEFW	6	9	0.22	0.55
NS/DDGO	1	1	< 0.05	< 0.05
NS/IEC	144	146	0.07	0.72
NSNI	57	59	0.09	0.81
NSNS	127	208	< 0.05	0.37
NSRW	26	29	< 0.05	0.10
SGCP	4	4	< 0.05	< 0.05
SGAS	50	85	< 0.05	0.34
SGTS	8	13	0.05	0.20
Total	515	1010	0.09	1.09

The number of whole-body dosimeters that have not been returned to the Radiation Safety Technical Services as part of TC activities amounted to a total of 102 from 2013, 62 from 2014, 229 from 2015, and 302 from 2016. Table 3.15 gives detailed information on the unreturned dosimeters from the past year. As a consequence, no measurements were performed, and thus no dose reports could be issued. Therefore, there is no information on the compliance with the IAEA Radiation Safety Regulations. Moreover, the actual dose information on the dosimeter might have faded already or been concealed by the environmental background. In addition, the financial implications are of concern as the total cost of each unreturned dosimeter, including both its commercial value and the associated administrative burdens, was assessed by the Office of Internal Oversight Services (OIOS) at € 107, resulting in a total cost of currently unreturned dosimeters of € 74,365. OIOS recommended that ‘charges should […] be applied to unreturned dosimeters, which represent a significant and avoidable cost and administrative burden for RSTSU’. TC is routinely updated on the status of unreturned dosimeters.

TABLE 3.15: NUMBER AND COST OF UNRETURNED WHOLE-BODY DOSIMETERS FROM TC ACTIVITIES IN 2016.

Division	Unreturned dosimeters	Total cost
TCAF	133	€ 14,231
TCAP	139	€ 14,873
TCEU	5	€ 535
TCLAC	25	€ 2,675
Total	302	€ 32,314

3.2 Extremity Doses

In the reporting period, 431 staff members of the IAEA were registered for extremity monitoring, of which 91 had been provided a fingering dosimeter, representing a decrease of 9% compared with the previous year. Of those, 79 workers received this service continuously. The distribution of equivalent doses to the extremities is illustrated in Figure 3.9. The monitoring results are further detailed according to organizational entity in Table 3.16. The average equivalent dose to the extremities was 0.75 mSv, with a maximum of 16.92 mSv. Eighty-one percent of monitored OEWs received an equivalent dose of less than 1 mSv.

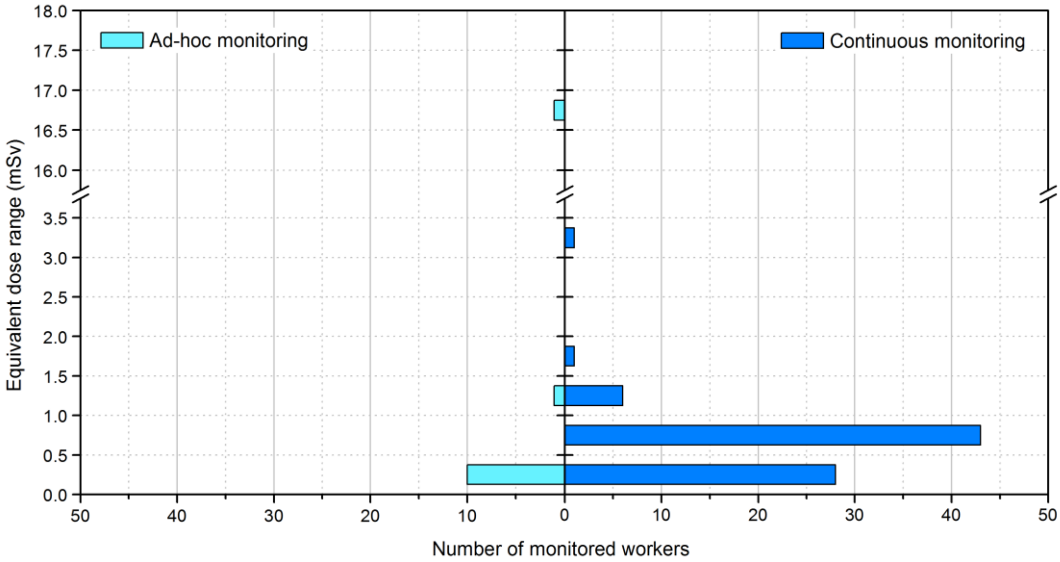


FIGURE 3.9: DISTRIBUTION OF EXTREMITY DOSE RECEIVED BY CONTINUOUSLY AND AD-HOC MONITORED IAEA STAFF MEMBERS IN 2016.

TABLE 3.16: EXTREMITY MONITORING FOR IAEA STAFF MEMBERS IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average equivalent dose (mSv)	Maximum equivalent dose (mSv)
MTGS	1	12	0.60	0.60
NAEL	7	19	0.37	0.74
NAFA	7	25	0.71	1.01
NAHU	3	20	0.18	0.20
NAPC	6	25	0.51	0.67
NEFW	3	18	6.14	16.92
NSNS	3	12	0.11	0.25
NSRW	9	81	0.70	1.28
SGAS	37	396	0.73	1.92
SGOB	1	1	0.31	0.31
SGOC	1	2	0.07	0.07
SGTS	7	78	0.32	0.46
SGVI	4	37	0.55	0.85
TCAF	2	2	0.05	0.10
Total	91	728	0.75	16.92

In the reporting period, 474 non-staff members were registered for extremity monitoring, of which 380 individuals had been provided a fingering dosimeter, representing an increase of 37% compared with the previous year. The distribution of equivalent dose to the extremities is illustrated in Figure 3.10 and further detailed according to organizational entity in Tables 3.17−3.18. The average equivalent dose to the extremities was 0.12 mSv, with a maximum of 8.62 mSv. Ninety-seven percent of non-staff members received an equivalent dose of less than 1 mSv.

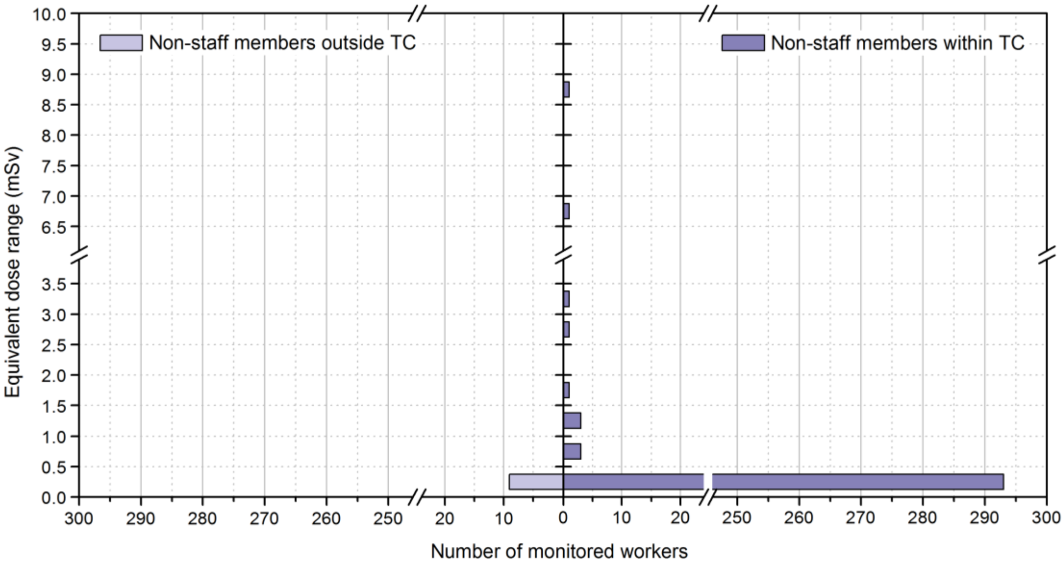


FIGURE 3.10: DISTRIBUTION OF EXTREMITY DOSE RECEIVED BY NON-STAFF MEMBERS IN 2016.

TABLE 3.17: EXTREMITY MONITORING FOR NON-STAFF MEMBERS INVOLVED IN TC ACTIVITIES IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
TCAF	84	69	< 0.05	0.30
TCAP	162	133	0.22	8.62
TCEU	51	48	< 0.05	< 0.05
TCLAC	74	61	0.11	1.49
Total	371	311	0.12	8.62

TABLE 3.18: EXTREMITY MONITORING FOR NON-STAFF MEMBERS OUTSIDE THE TC PROGRAMME IN 2016.

Division/Section	Number of monitored workers	Number of measurements	Average total effective dose (mSv)	Maximum total effective dose (mSv)
NAFA	1	14	0.23	0.23
NEFW	3	3	0.10	0.29
SGAS	5	20	0.26	0.36
Total	9	37	0.20	0.36

3.3 Sample Processing Time

The average processing time between a sample being received and the associated dose being registered in the Dose Management System is summarized for the different services in Table 3.19. Due to expansion of the integrated alpha spectrometry cabinet with support from the Government of Switzerland, the average processing time for radiobioassay measurements of alpha-emitting radionuclides in urine was reduced by 43%.

TABLE 3.19: PROCESSING TIME BETWEEN SAMPLE RECEIPT AND REGISTRATION OF ASSOCIATED DOSE IN 2016.

Method	Average processing time (days)	Minimum processing time (days)
Whole-body thermoluminescence dosimetry	4	< 1
Extremity thermoluminescence dosimetry	6	< 1
Active personal dosimetry	6	< 1
Body activity measurements	< 1	< 1
Radiobioassay analysis of urine (alpha spectrometry)	28	3
Radiobioassay analysis of urine/saliva (beta spectrometry)	13	1
Radiobioassay analysis of urine (gamma spectrometry)	5	< 1
Radiobioassay analysis of faeces (alpha spectrometry)	–	–

4 Other Operational Services

4.1 Individual Monitoring Service Group

4.1.1 Radiation Monitoring Instruments and Personal Protective Equipment

The RSTSU provided loan services for radiation monitoring instruments and personal protective equipment (PPE) as requested and as available through the RMPS Desk intranet portal. As shown in Figure 4.1, the demand for instrument loan services continued to increase significantly in the reporting period, while the number of PPE items distributed to staff members maintained the high level of 2015. The amount of radiation monitoring instruments loaned and personal protective equipment provided to the different departments of the IAEA in 2016 is detailed in Table 4.1 and illustrated in Figure 4.2.

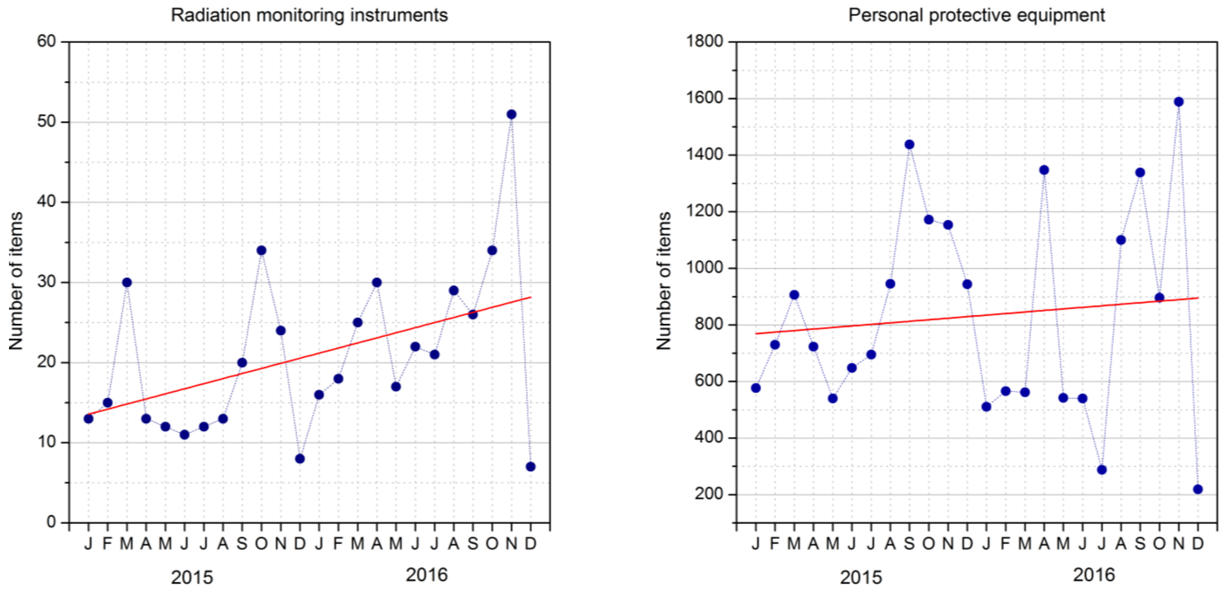


FIGURE 4.1: LOAN SERVICES FOR RADIATION MONITORING INSTRUMENTS AND PROVISION OF PERSONAL PROTECTIVE EQUIPMENT (2015 AND 2016).

TABLE 4.1: DEVELOPMENT OF LOAN SERVICES FOR RADIATION MONITORING INSTRUMENTS AND PERSONAL PROTECTIVE EQUIPMENT.

Item	Number of items				
	2012	2013	2014	2015	2016
Overalls and overcoats	581	631	742	1424	1065
Overshoes (pairs)	1143	1374	1112	1804	1584
Gloves (pairs)	3407	3587	4241	5538	5391
Masks (including gas filters)	728	898	579	1022	1013
Caps and hoods	596	505	460	674	669
Radiation monitoring equipment	115	164	101	205	296
Total	6570	7159	7235	10667	10018

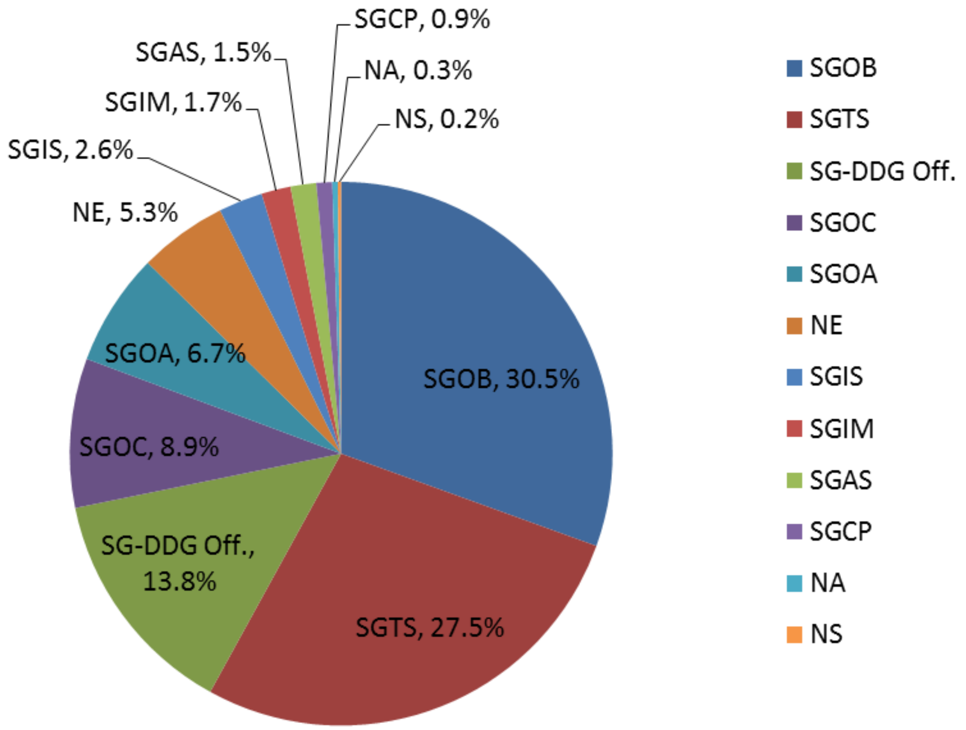


FIGURE 4.2: DISTRIBUTION OF PERSONAL PROTECTIVE EQUIPMENT REQUESTED BY THE DEPARTMENT OF SAFEGUARDS AND OTHER DEPARTMENTS IN 2016.

4.1.2 Dosimeter Seals

A special service applying dosimeter seals at selected facilities in Member States is used by SG. While the monitoring is not related to occupational monitoring of IAEA staff members, the same detector type and measurement method is used. The service is referred to as ‘yes/no monitoring’. In the reporting period, a total of 111 TLD chips (including reference dosimeters) incorporated in 31 yes/no monitors were read out and evaluated. Due to equipment failure beyond economical repair in December 2016, the Equipment Handling and Storage Team, SGTS/TVL, was informed of the unavoidable discontinuation of the service, which is outside RSTSU’s responsibility.

4.2 Operational Radiation Monitoring Service Group

The group gave technical support to the Radiation Protection Officers of SGAS and NA. ORMSG assisted with review of safety documentation such as Safety Analyses Reports, Radiation Protection Programmes and several working procedures for the routine work in the laboratories. Assistance with the radiation monitoring programme was also provided for the SG ERML at the VIC.

4.2.1 Workplace Monitoring

The ORMSG provides services at the IAEA Seibersdorf premises for the Departments of Nuclear Sciences and Applications (NA), Safeguards (SG) and Management (MT). In 2016, the ORMSG performed routine, special and emergency radiation monitoring in designated areas of the former SGAS Nuclear Material Laboratory (NML), also known as the Safeguards Analytical Laboratory (SAL). During the transition of SGAS operations from the SAL to the new NML, routine, special and emergency radiation monitoring was also done in the new NML, including 60 rooms in controlled areas and 10 rooms in supervised areas. Thirteen joint radiation safety documents were established in 2016. Routine, special, and emergency radiation monitoring was also performed in NA laboratories, including 13 rooms in controlled areas and 9 rooms in supervised areas.

Assistance with the radiation monitoring programme was provided for the SG ERML in the VIC. For this laboratory, ORMSG also provides quality management system coverage under the ISO/IEC 17025:2005 accreditation of the Testing Laboratory.

The ORMSG and ERML performed 48103 workplace monitoring measurements in SAL, NML, NA and ERML laboratories, an increase of 1%. The ORMSG performed 25932 measurements in the NML, the SAL and in the NA laboratories, an increase of 1%. Calibration services were provided for 372 radiation monitoring instruments including portable and fixed dose rate and surface contamination meters, a decrease of 9%.

A total of 18 waste drums (burnable and non-burnable SAL 2 drums, ERML 16 drums) were measured and transferred to Nuclear Engineering Seibersdorf (NES), a decrease of 51% from 2015 and at the same level as 2014. The decrease of 51% is attributed to the increase in waste disposal 2015 due to the move from SAL to NML.

Monitoring activities are summarized in Table 4.2. The measurements performed in 2015 are included in the table for comparison. The differences in the measurement numbers in consecutive years can be explained by different aspects of the work during the transition from the SAL to the NML in 2015 and due to the increased number of surface contamination measurements in 2016 for SGTS rooms in the VIC. The number of measurements of the activity of alpha emitters on air filter samples was higher in 2016 than in 2015. This level is expected to remain due to the increased number of air monitors in the NML.

TABLE 4.2: MONITORING ACTIVITIES PERFORMED BY ORMSG IN SEIBERSDORF (NML, SAL, NA) AND AT IAEA HEADQUARTERS (ERML) IN 2016. (Numbers for 2015 are in parenthesis.)

Dose rate measurements for photon emitters:
• Routine dose rate measurements in the laboratories
NML: 2123 (1864)// SAL: 0 (3500) // NA: 2606 (1258)
• Dose rate measurements on filter boxes
(lab ventilation systems)
NML: 1344 (1344) // SAL: 408 (408) // NA: 192 (192)
• Test reports for dose rate measurements
(i.e. non-routine requests)
NML: 19 (1) // SAL: 0 (1) // NA: 60 (17)
	6752
	(8585)

Measurement of surface contamination by alpha, beta and gamma emitters
(applied to workplace monitoring):
• Routine surface contamination measurements in the labs
NML: 10274 (8604) // SAL: 1275 (3500) // NA: 1762 (1152)
• Routine surface contamination measurements at glove box exhausts
NML: 20 (20) // SAL: 68 (0)
• Test reports for surface contamination measurements
(i.e. non-routine requests)
NML: 57 (14) // SAL: 0 (5) // NA: 205 (10) // VIC: 888 (0)
	14549
	(13305)

Measurement of surface contamination by alpha, beta and gamma emitters (applied to returned equipment)*	9141 (9048)
Measurement of surface contamination by alpha, beta and gamma emitters (applied to metal seals)*	12451 (12594)
Measurement of surface contamination by alpha, beta and gamma emitters (applied to environmental samples)*	524 (476)
Measurement of gross Pu-content in waste drums	18 (37)
Leakage test of radioactive sources • NML: 103 (12) // SAL: 2 (0) // NA: 133 (10) // ERML*: 29 (0)	267 (22)
Measurement of activity of alpha emitters on air filter samples by alpha spectrometry and gross alpha counters • NML: 3811 (3260) // SAL: 520 (477) // NA: 44 (55) // ERML*: 26 (0)	4401 (3792)
Total ORMSG and ERML	48103 (47859)

*Performed in Equipment Radiation Monitoring Laboratory (ERML) which is part of the Testing Laboratory

4.2.2 Calibration

ORMSG also provides calibration of monitoring instruments. Portable dose rate and surface contamination radiation monitoring instruments were subjected to annual calibration. Equipment is available for IAEA field operations inter alia, for loan to SG inspectors and other in-house users.

A total of 372 radiation monitoring instruments (portable and fixed dose rate and surface contamination meters) were subjected to routine annual calibration, a decrease of 9%. These instruments are made available at the IAEA Laboratories in the VIC, Seibersdorf and Monaco and at the loan desk for IAEA field operations, SG inspectors and other in-house users. The calibrations are summarized in Table 4.3.

TABLE 4.3: CALIBRATIONS PERFORMED BY ORMSG IN 2016 (Numbers for 2015 are in parenthesis).

Type of equipment	Customer	Number of equipment
Dose rate meters	NA	43 (26)
	SGTS	10 (1)
	Loan Service	50 (35)
	NML	43 (58)
	SAL	1 (13)
	IEC	38 (27)
	Monaco	5 (0)
	Total	**190 (160)**
Surface contamination meters	NA	21 (37)
	SGTS	27 (5)
	Loan Service	35 (32)
	NML	78 (129)
	SAL	7 (27)
	IEC	8 (13)
	Monaco	6 (8)
	Total	**182 (251)**

4.3 Training Activities

In the frame of training for OEWs both IMSG and ORMSG contributed to enhance the radiation safety in the IAEA premises. More than 300 staff members were provided training in 2016. The training provided is summarized Table 4.4.

TABLE 4.4: TRAINING PROVIDED BY IMSG AND ORMSG IN 2016.

Date	Title	Department / Division	Attendees
25 January 2016	NML and SAL On-call Services Training for SGAS Emergency Controller and SFMS Technicians	SGAS / NA	4
01-04 February 2016	SG RP Refresher	SG	21
17 February 2016	Radiation Protection Course for 2016 SG Traineeship Programme	SG	20
23 February 2016	NML HP Training for Newcomers	SGAS	1
14-17 March 2016	ICAS 64	SG	17
01 April 2016	NML Introduction	ISS Cleaners (SFMS)	4
25 April 2016	NML HP Training for Newcomers	SGAS	2
27 April 2016	NML Introduction	SPF (SFMS)	2
29 April 2016	SGAS RP Refresher	SGAS	25
06 May 2016	NML Introduction	SPF (SFMS)	3
13 May 2016	NML Introduction	ISS Cleaners (SFMS) + SGAS	4
09 May 2016	Refresher for On-Call EC NML	SGAS	1
06 June 2016	NML Introduction	SPF (SFMS)	3
14-16 June 2016	SG RP Refresher	SG	20
16 June 2016	NML Introduction	SPF (SFMS)	2
20 June 2016	RP Module T2	NA	25
17 August 2016	NML HP Training for Newcomers	SGAS	1
23 August 2016	NML Introduction	SPF (SFMS)	1
08 September 2016	NML Introduction	ISS Cleaners (SFMS) + SGAS	4
14 September 2016	NML Introduction	SGAS + SFMS	2
14 September 2016	RP Refresher	NSNI	9
16 September 2016	NML Introduction (Maintenance 2016)	external Contractors (SFMS)	10
03 November 2016	NA RP Refresher (module T2)	NA	18
7-10 November	ICAS 65	SG	10
07 November 2016	SG SSST (Safeguards Support staf+2 observesf)	SG	28
15-17 November	SG RP Refresher	SG	16
18 November 2017	NA RP Refresher (module T2)	NA	8
28 November 2016	DIR/RPO Training	All	25
05 December 2016	NA RP Refresher (module T2)	NA	17
12 December 2016	DIR/RPO Training	All	15
16 December 2016	DIR/RPO Training (Laboratory session)	NA, SG, MTGS	7
Total number of training sessions: 31		**Total number of trainees:**	325

5 Recommendations

Directors in Charge and RPOs can use this report to assist in assessing the effectiveness of their radiation safety programmes. Dose trends and details are provided for this use. The report reflects the trend of the past five years showing steadily increasing demands for monitoring services. RPOs are requested to review their programmes to ensure monitoring meets their needs and to request additional services from the RSTSU as far in advance as possible. Programme changes should be discussed with enough notice for RSTSU to request resources during biennial budget discussions. Should such programmatic changes not be anticipated during the development of the budget, RSTSU may require the requesting organizational group to transfer funds during the financial year.

Acronyms

APD......................Active personal dosimetry
BSS.....................Basic Safety Standards
ERML.................Equipment Radiation Monitoring Laboratory
ICRP...................International Commission on Radiation Protection
ICRU ....International Commission on Radiation Units and Measurements
IMSG..................Individual Monitoring Service Group
LSC.....................Liquid Scintillation Counting
MT......................Department of Management
NA ....Department of Nuclear Sciences and Applications
NE.......................Department of Nuclear Engineering
NML...................Nuclear Material Laboratory
NS.......................Department of Nuclear Safety and Security
OEW...................Occupationally Exposed Worker
OIOS...................Office of Internal Oversight Services
ORDG.................Offices Reporting to the Director General
RMPS ....Radiation Monitoring and Protection Services
RPO....................Radiation Protection Officer
RSNSR ....Radiation Safety and Nuclear Security Regulator
RSTSO ....Radiation Safety Technical Services Officer
RSTSU ....Radiation Safety Technical Services Unit
SAL ....Safeguards Analytical Laboratory
SG.......................Department of Safeguards
TC.......................Department of Technical Cooperation
TLD ....Thermoluminescence dosimetry
VIC.....................Vienna International Centre

Annex:
Dose Quantities for Individual Monitoring

The following definitions of operational and protection dose quantities used throughout this report are based on the definitions given in *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (BSS), General Safety Requirements Part 3*, unless otherwise noted.

Committed effective dose, $E(\tau)$:

The quantity $E(\tau)$, defined as:

$$E(\tau) = \sum_{\mathrm{T}} w_{\mathrm{T}} \cdot H_{\mathrm{T}}(\tau)$$

where $H_{\mathrm{T}}(\tau)$ is the committed equivalent dose to tissue or organ T over the integration time τ elapsed after an intake of radioactive substances and w_{T} is the tissue weighting factor for tissue or organ T. When τ is not specified, it will be taken to be 50 years for adults and the time to age 70 years for intakes by children.

Committed equivalent dose, $H_{\mathrm{T}}(\tau)$:

The quantity $H_{\mathrm{T}}(\tau)$, defined as:

$$H_{\mathrm{T}}(\tau) = \int_{t_0}^{t_0+\tau} \dot{H}_T(\tau)$$

where t_0 is the time of intake, $\dot{H}_{\mathrm{T}}(\tau)$ is the equivalent dose rate at time *t* in tissue or organ T and τ is the integration time elapsed after an intake of radioactive substances. When τ is not specified, it will be taken to be 50 years for adults and the time to age 70 years for intakes by children.

Effective dose, *E*:

The quantity *E*, defined as a summation of the tissue or organ equivalent doses, each multiplied by the appropriate tissue weighting factor:

$$E = \sum_{\mathrm{T}} w_{\mathrm{T}} \cdot H_{\mathrm{T}}$$

where H_{T} is the equivalent dose in tissue or organ T and w_{T} is the tissue weighting factor for tissue or organ T. From the definition of equivalent dose, it follows that:

$$E = \sum_{\mathrm{T}} w_{\mathrm{T}} \cdot \sum_{\mathrm{R}} w_{\mathrm{R}} \cdot D_{\mathrm{T,R}}$$

where w_{R} is the radiation weighting factor for radiation type R and $D_{\mathrm{T,R}}$ is the average absorbed dose in the tissue or organ T delivered by radiation type R.

> ⓘ The SI unit for effective dose is joule per kilogram (J/kg), termed the sievert (Sv). An explanation of the quantity is given in Annex B of International Commission of Radiological Protection Publication 103[2].

Equivalent dose, H_{T}:

[2] International Commission on Radiological Protection. *The 2007 Recommendations of the International Commission on Radiological Protection.* ICRP Publication 103, *Ann. ICRP* **37** (2−4), 2007.

The quantity $H_{T,R}$, defined as:

$$H_{T,R} = w_R \cdot D_{T,R}$$

where $D_{T,R}$ is the absorbed dose delivered by radiation type R averaged over a tissue or organ T and w_R is the radiation weighting factor for radiation type R. When the radiation field is composed of different radiation types with different values of w_R, the equivalent dose is:

$$H_T = \sum_R w_R \cdot D_{T,R}$$

- ⓘ The SI unit for equivalent dose is joule per kilogram (J/kg), termed the sievert (Sv). An explanation of the quantity is given in Annex B of International Commission of Radiological Protection Publication 103.
- ⓘ Equivalent dose is a measure of the dose to a tissue or organ designed to reflect the amount of harm caused.
- ⓘ Equivalent dose cannot be used to quantify higher doses or to make decisions on the need for any medical treatment relating to deterministic effects.
- ⓘ Values of equivalent dose to a specified tissue or organ from any type(s) of radiation can be compared directly.

Intake, I:

1. The act or process of taking radionuclides into the body by inhalation or ingestion or through the skin.
   - ⓘ Other intake pathways are injection (important in nuclear medicine) and intake via a wound, as distinguished from intake through (intact) skin.
2. The activity of a radionuclide taken into the body in a given time period or as a result of a given event.

Personal dose equivalent, $H_p(d)$:

The dose equivalent in soft tissue below a specified point on the body at an appropriate depth d.

- ⓘ Parameter used as a directly measurable proxy (i.e. substitute) for equivalent dose in tissues or organs or (with $d = 10$ mm) for effective dose, in individual monitoring of external exposure.
- ⓘ The recommended values of d are 10 mm for strongly penetrating radiation and 0.07 mm for weakly penetrating radiation for whole-body monitoring.
- ⓘ $H_p(0.07)$ is used for monitoring for hands and feet for all radiation types.
- ⓘ $H_p(3)$ is used for monitoring exposure of the lens of the eye.
- ⓘ ‘Soft tissue’ is commonly interpreted as the International Commission on Radiation Units and Measurements (ICRU) sphere.