IAEA TECDOC SERIES

IAEA-TECDOC-1747

The Information System on Occupational Exposure in Medicine, Industry and Research (ISEMIR): Industrial Radiography

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THE INFORMATION SYSTEM ON OCCUPATIONAL EXPOSURE IN MEDICINE, INDUSTRY AND RESEARCH (ISEMIR): INDUSTRIAL RADIOGRAPHY

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THE INFORMATION SYSTEM ON OCCUPATIONAL EXPOSURE IN MEDICINE, INDUSTRY AND RESEARCH (ISEMIR): INDUSTRIAL RADIOGRAPHY

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FOREWORD

Industrial radiography work is often carried out under difficult working conditions, such as in confined spaces, in extreme cold or heat, or during the night. Working under such adverse conditions might result in operational situations in which occupational radiation protection may be compromised. Experience shows that incidents involving industrial radiography sources have sometimes resulted in high doses to workers, causing severe health consequences such as radiation burns and, in a few cases, death.

It has been long known that there is significant potential for industrial radiography personnel to receive non-trivial occupational exposure. However, a global perspective is lacking, as is the availability of a systematic means for improving occupational radiation protection in industrial radiography worldwide.

In 2006, the IAEA published IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles, jointly sponsored by the European Atomic Energy Community, the Food and Agriculture Organization of the United Nations (FAO), the International Labour Organization (ILO), the International Maritime Organization, the OECD Nuclear Energy Agency (OECD/NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO). That publication sets out the fundamental safety objective and principles of protection and safety. In 2014, the IAEA published IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (the BSS), jointly sponsored by the European Commission, the FAO, the ILO, OECD/NEA, the PAHO, UNEP and the WHO. The BSS sets out the requirements that are designed to meet fundamental safety objectives and to apply the principles specified in IAEA Safety Standards Series No. SF-1. The establishment of safety requirements and provision of guidance on occupational radiation protection is a major component of the support for radiation protection and safety provided by the IAEA to its Member States.

This publication was developed under the IAEA's statutory responsibility to provide for the worldwide application of safety standards for the protection of people against exposure to ionizing radiation. It details the results of the Information System on Occupational Exposure in Medicine, Industry and Research (ISEMIR) project during 2009–2012 and, in particular, the activities of the Working Group on Industrial Radiography (WGIR). The ISEMIR project arose from the Occupational Radiation Protection International Action Plan (approved by the IAEA Board of Governors in September 2003), which identified in Action 7 the need to establish networks for the exchange of information on experience and lessons learned between interested parties.

The IAEA acknowledges the significant work of the members of the WGIR and would also like to thank the many individual industrial radiographers, non-destructive testing companies and regulatory bodies who participated in the survey. The IAEA officer responsible for this publication was J.C. Le Heron of the Division of Radiation, Transport and Waste Safety.

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1. INTRODUCTION

1.1. BACKGROUND TO ISEMIR

The International Atomic Energy Agency (IAEA) initiated in early 2009 the Information System on Occupational Exposure in Medicine, Industry and Research, referred to as the ISEMIR project.

The catalyst for the ISEMIR project was the experience of the Information System on Occupational Exposure (ISOE) of nuclear power plant operators around the world, where having a database that contained detailed information on operational occupational doses across many nuclear power plants enabled the comparison and benchmarking of doses for specific occupations, functions and tasks [1]. This in turn enabled the assessment of the impact of various radiation protection actions. As the ISOE database became populated with data covering many years, dose trends were also able to be analysed. If such an approach was successful for nuclear power plant workers, perhaps a similar approach could be utilized in the non-nuclear domain — i.e. medicine, industry and research.

The ISEMIR project was overseen by an Advisory Group, whose first task was to identify a limited number of specific areas of radiation use in medicine, industry and research where non-trivial occupational exposures occur, and which might benefit from such an approach as described above.

The Advisory Group of ISEMIR identified two such areas of radiation use, namely interventional cardiology (IC) and industrial radiography (IR), and two separate working groups were formed to address these areas. This TECDOC will discuss only IR. A companion TECDOC covers IC.

1.2. WORKING GROUP ON INDUSTRIAL RADIOGRAPHY

The Working Group on Industrial Radiography (WGIR) met for the first time in January 2010. The membership of WGIR is given in Appendix V, and is comprised of professionals with experience of working for non-destructive testing (NDT) companies, client companies, NDT societies, technical service organizations, including education, training and inspection, and regulatory bodies.

The mandate for WGIR was to gain a world-wide overview of occupational exposures and radiation protection of individuals in IR; to identify both good practices and shortcomings, and hence define actions to be implemented for assisting each of industry, clients and regulatory bodies in improving occupational radiation protection; to propose recommendations for harmonizing monitoring procedures; and to set up a system for regularly collecting and analyzing occupational doses for individuals in IR and for reporting incidents, and for dissemination of this information to improve occupational radiation protection.

1.3. ACTIVITIES OF THE WGIR

This TECDOC presents the main activities of the WGIR and the ensuing results – namely the worldwide survey of occupational radiation protection in industrial radiography, the road map

and the ISEMIR international database, and these are described in successive sections. The worldwide survey underpinned the subsequent activities of the WGIR. Its scope included individual industrial radiographers, NDT companies and radiation protection regulatory bodies from as many different countries and regions of the world, and its purpose was to obtain a "snapshot' of all aspects of current occupational radiation protection practice in IR. The results of the survey were then used to develop the roadmap and the ISEMIR international database.

Additional information on the WGIR is also available at the WGIR webpages: http://www-ns.iaea.org/tech-areas/communication-networks/norp/isemir-wgir.htm

2. WORLDWIDE SURVEY OF OCCUPATIONAL RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY

2.1. INTRODUCTION

As part of its initial actions, WGIR sought to gain insight into occupational radiation protection in industrial radiography world-wide using questionnaires. Three questionnaires were developed and distributed.

The following sections provide full details on this survey. Various aspects of the survey have also been presented at several conferences and meetings.

2.2. METHOD

Three questionnaires were developed — one addressed to individual industrial radiographers, another to NDT companies, and a third to national or state radiation protection regulatory bodies. Topics addressed by each questionnaire included:

- training in radiation protection;
- incidents;
- safety of the radiographer, the public and sources;
- inspections;
- emergency plans;
- individual monitoring.

The questionnaire for individual industrial radiographers was comprised of 14 main questions. The NDT company questionnaire and the regulatory body questionnaire were more complex, comprising 31 and 29 main questions, respectively.

To help elicit a wider response, both the radiographer questionnaire and the NDT company questionnaire were available in several languages — Chinese, English, French, German, Portuguese, Russian and Spanish, with the addition of Dutch for the radiographer questionnaire. The Regulatory Body questionnaire was in English only. The English versions of the questionnaires are reproduced in Appendix IV.

The questionnaires were distributed widely over an approximate one year period (mid-2010 to mid-2011), primarily using the industry and NDT society contacts of WGIR members and using IAEA contacts with regulatory bodies. Responses from radiographers were anonymous unless the responder wished to be identified.

2.3. RESULTS

The survey produced a large amount of information, and this section will present the main findings only from the three questionnaires, while the detailed results (including regional analysis) in the form of tables, figures and notes are given in Appendices I-III. In many of the responses to the questionnaires, not all questions were answered. In calculating the percentages given in this section, ‘no reply’ answers were excluded from the totals for that question, unless otherwise stated. For questions where the questionnaire instruction was to

'*tick all options applicable*', then a 'no reply' for a given option was interpreted as meaning that that option was not applicable, and hence equivalent to being a 'no', and these were included in the totals for that question.

2.3.1. Caveats

Because of the nature of the distribution of the questionnaires to individual industrial radiographers and to NDT companies, it is likely that those approached represent the better end of the practice spectrum. In the case of the industrial radiographer survey there were regional biases, with two thirds of responses coming from Europe and North America. Further, one quarter of all industrial radiographer responders were the only responder from that NDT company, and hence were likely to have been the radiation protection officer (RPO), or at least a person with an interest in radiation protection. Hence, it is recognised that the survey results cannot purport to be truly representative of the worldwide practice of industrial radiography and all results must be interpreted with this caution. Further, many of the questions involved a radiographer or a company assessing their own habits or performance, and hence are subject to distortions of perception versus reality, thus placing a further caveat on those results.

The distribution of the regulatory body questionnaire was systematic – contact was attempted for all IAEA Member States. However, not all regulatory bodies responded, and some of those not responding were regulatory bodies of large countries.

Notwithstanding the above caveats, some useful insight into current radiation protection practice in industrial radiography was gained, as summarized below. Further details are given in Appendices I to III.

2.3.2. Number of responses

2.3.2.1. Individual industrial radiographer operators

There were 432 responses from industrial radiography operators, from approximately 150 different NDT companies, and 31 different countries. Further details are given in Appendix I, Section I.2, Tables 5-6.

Nearly 200 radiographers provided their approximate annual workload (number of exposures) in 2009, with an average of just under 3000 exposures and a median of 1000. Further details are given in Appendix I, Section I.2.8.2, Table 41.

In 2009, the radiation sources being used by the radiographers were as follows:

- Approximately three-quarters of the radiographers were using Ir-192 sources, with a mean and median activity of about 40 Ci (1.5 TBq);
- about one-third were using Se-75 sources, with a mean and median activity of about 40 Ci (1.5 TBq);
- about 10% were using Co-60 sources, with a mean and median activity of about 40 Ci (1.5 TBq); and
- about one-half were using X ray equipment, with a mean kVp of 230 kV.

Further details on radiation sources used are given in Appendix I, Section I.2.8.3, Tables 42-50.

2.3.2.2. NDT companies

There were 95 responses from NDT companies performing industrial radiography, from 29 different countries. Of the 95 NDT companies, 73 performed both gamma and X ray radiography, 14 performed gamma radiography only, and 8 X ray radiography only.

82 NDT companies gave information on their number of radiographers, which could be summarized as follows:

- The mean number of fulltime radiographers per NDT company was 39, with a median of 17;
- One-half of the NDT companies employed less than 20 fulltime radiographers;
- Eight NDT companies employed more than 100 fulltime radiographers;
- Few NDT companies (14 out of 81) stated that they employed part-time radiographers.

74 NDT companies gave further information on their radiographers, as follows:

- On average, three-quarters of the radiographers in a company were involved in site radiography, and half were performing site radiography fulltime;
- On average, 60% of the radiographers in a company were using both gamma sources and X rays, 25% gamma sources only, and 15% X rays only.

Almost all NDT companies (97%, 91 out of 94) stated that they have an RPO or a radiation protection expert (RPE) included in their organization. Of these, the majority (88%, 78 out of 89) report directly to the managing director.

Further details on the responding NDT companies are given in Appendix II, Section II.2, Table 67, and Section II.7, Tables 219- 227.

2.3.2.3. Regulatory bodies

Responses were received from 59 regulatory bodies (55 national regulatory bodies and 4 state regulatory bodies[1]) from 55 countries. Contact had been attempted with 142 radiation protection regulatory bodies from 133 countries, giving a participation rate of about 40%. The responding regulatory bodies have jurisdiction over countries whose summed population is about 40% of the world's total population. Further details on the responding regulatory bodies are given in Appendix III, Section III.2, Table 228.

[1] Some Member States have a federal system of government, where each 'state' within the country has jurisdiction over the use of radiation in industrial radiography.

2.3.3. Radiation protection training and qualifications of industrial radiographers

2.3.3.1. Individual industrial radiographers

The results from the individual industrial radiographers are summarized as follows:

- 30% of radiographers (121 out of 408) had level 1 as their highest level of NDT training; 54% (221 out of 408) had level 2; and 16% (66 out of 408) had level 3[2].
- The majority of radiographers stated that radiation protection training was included in their NDT training on radiographic testing – 89% (286 out of 321) for level 1; 86% (249 out of 289) for level 2; and 53% (47 out of 88) for level 3.
- 85% of radiographers (364 out of 427) stated that they had received separate radiation protection training and, of these, most (87%, 312 out of 358) stated that they had a formal qualification in radiation protection.
- Only 8 out of 432 responding radiographers (2%) appeared to have not had radiation protection training, either as part of the NDT training or as separate training.
- 89% of radiographers (375 out of 422) stated that procedures for emergencies were included in the radiation protection training, and of these:
    - Two-thirds (247 out of 369) said that the training included practical exercises for creating a safe situation until the source is able to be recovered;
    - 57% (195 out of 342) said that the training included practical exercises for source recovery.
- Three-quarters of radiographers (302 out of 402) stated that they were not allowed to perform a source recovery on their own without first contacting a specialized source recovery person.
- Almost all radiographers (96%, 410 out of 425) felt sufficiently well qualified and trained to be able to work safely and reliably.
- 10% of radiographers (40 out of 417) stated that they did not feel well prepared for an emergency situation. About one-half of these had had no training in creating a safe situation or in source recovery, and most were not allowed to perform source recovery.

Further details on radiographer radiation protection training are given in Appendix I, Section I.2.2, Tables 7–20.

2.3.3.2. NDT companies

The results from the NDT companies are summarized as follows:

[2] NDT training is typically structured around three levels of training, with level 1 being the lowest level of training and level 3 the highest. Qualification and certification of NDT personnel in accordance with International Standards such as ISO 9712 (Non-destructive testing – Qualification and certification of personnel) and aligned standards helps to ensure that people are competent, and assists global safety standards.

- Almost all NDT companies (98%, 93 out of 95) stated that they provide or facilitate radiation protection training for their radiographers. Of these NDT companies:
    - 72% provide within the company initial theoretical radiation protection training, with a mean duration of 21 hours;
    - 69% provide within the company initial practical radiation protection training, with a mean duration of 21 hours;
    - 66% provide within the company refresher theoretical radiation protection training, with a mean duration of 10 hours, and a mean interval between training of 13 months;
    - 49% provide within the company refresher practical radiation protection training, with a mean duration of 9 hours, and a mean interval between training of 10 months;
    - 65% provide outside the company initial theoretical radiation protection training, with a mean duration of 32 hours;
    - 47% provide outside the company initial practical radiation protection training, with a mean duration of 23 hours;
    - 51% provide outside the company refresher theoretical radiation protection training, with a mean duration of 15 hours, and a mean interval between training of 34 months;
    - 31% provide outside the company refresher practical radiation protection training, with a mean duration of 16 hours, and a mean interval between training of 33 months.
- Combining the responses for training that occurs within and outside the company gave:
    - Nearly all NDT companies (96%, 89 out of 93) provided initial theoretical radiation protection training, either inside or outside the company or both. Only 4 NDT companies responded that they provided neither.
    - Mean initial radiation protection training (theory) – 37 hours.
    - Most NDT companies (82%, 76 out of 93) provided initial practical radiation protection training, either inside or outside the company or both. 17 NDT companies responded that they provided neither.
    - Mean initial radiation protection training (practical) – 30 hours.
    - Most NDT companies (83%, 77 out of 93) provided refresher theoretical radiation protection training, either inside or outside the company or both. 16 NDT companies responded that they provided neither.
    - Mean refresher radiation protection training per 5 years (theory) – 90 hours.

- Just over half the NDT companies (58%, 54 out of 93) provided refresher practical radiation protection training, either inside or outside the company or both. 39 NDT companies responded that they provided neither.

- Mean refresher radiation protection training per 5 years (practical) – 90 hours.

- Just over half of NDT companies (49 out of 92) stated that they provide different radiation protection training for gamma sources and for X ray sources.

- With respect to training on specific aspects of emergency preparedness and response:

    - Almost all (90 out of 92) stated that the training included emergency procedures;

    - 84% (77 out of 92) stated that the training included practical exercises for creating a safe situation;

    - 66% (60 out of 91) stated that the training included practical exercises for source recovery. There appeared to be a regional difference between Asia-Pacific (84%) and Latin America (74%), and the remaining regions — Africa (50%), North America (50%) and Europe (46%).

- The majority of NDT companies stated that radiation protection training was included as part of NDT training in radiographic testing in their country – 86% for NDT level 1, 75% for NDT level 2, and 49% for NDT level 3. When results for the same country were combined, and contradictory results excluded, the percentages increased to 100% for level 1, 94% for level 2, and 57% for level 3.

- 92% of NDT companies stated that they provide radiation protection training in addition to that contained in the NDT training.

Further details on the NDT company responses on radiographer radiation protection training are given in Appendix II, Section II.3, Tables 68–89.

2.3.3.3. Regulatory bodies

The results from the regulatory bodies are summarized as follows:

- Almost all regulatory bodies (58 out of 59) stated that they require a person wishing to perform on-site radiography to have had radiation protection training to an acceptable level.

    - Of these, about 70% (35 out of 50) considered the radiation protection training given as part of the NDT training on radiographic testing was acceptable;

    - About 80% (43 out of 53) considered that radiation protection training given as a separate training course was acceptable;

    - About 40% (22 out of 56) considered both as being acceptable.

- Over 80% of the regulatory bodies (43 out of 53) stated that they had the same radiation protection training requirements for using gamma sources as for using X ray machines.

- Nearly 90% of the regulatory bodies (51 out of 58) stated that they required the radiation protection training to include both theoretical and practical training.

- 70% of the regulatory bodies (41 out of 57) stated that the radiation protection training had to include practical exercises for creating a safe situation in an emergency until the source is able to be recovered.

- A smaller percentage (63%, 34 out of 54) stated that the radiation protection training had to include practical exercises for source recovery in an emergency. This lower figure reflects that in many countries, source recovery is restricted to specialised persons.

- The majority of regulatory bodies (90%, 50 out 57) stated that they required the passing of an examination at the end of the radiation protection training, with:

    - 44% requiring a theory only examination;

    - 56% requiring the examination to be both theoretical and practical.

- Separate radiation protection training was allowed to be provided by:

    - the regulatory body in 42% (18 out of 43) of responses;

    - educational institutes in 56% of responses (24 out of 43);

    - NDT companies in 44% of responses (19 out of 43);

    - private radiation protection consultants in 47% of responses (20 out of 43).

- 70% of regulatory bodies (41 out of 59) stated that they required refresher training in radiation protection for persons performing on-site radiography.

    - For these regulatory bodies, the average interval between refresher courses was 4 years;

    - Over one-half of the regulatory bodies (21 out of 38) required an examination as part of the refresher training.

Further details on the regulatory body responses on radiographer radiation protection training are given in Appendix III, Section III.3, Tables 229–241.

2.3.3.4. Radiation Protection Officers (RPOs)

Almost all regulatory bodies (57 out of 59) stated that they require a person wishing to act as an RPO for a company that performs on-site radiography to have had radiation protection training to an acceptable level. Of these:

- Nearly 70% (39 out of 56) stated that the regulatory body would require a higher level of radiation protection training for the RPO than that for an operator;

- About 80% (42 out of 52) stated that there was an examination.

Further details on the regulatory body responses on RPO radiation protection training are given in Appendix III, Section III.3.3, Tables 242–244.

Just over one-half of the radiographers (232 out of 415) stated that there is always a qualified radiation safety expert (RPO or RPE) on the work site, supervising the job, when on-site radiography is being performed; and a further one-third said that an RPO was sometimes present. Of the 26 'never' responses, almost all were radiographers with either level 2 or level 3 NDT training. Further details are given in Appendix I, Section I.2.3, Tables 21–22.

2.3.4. Incidents (deviations, near misses and accidents)

2.3.4.1. Individual industrial radiographers

The results from the individual industrial radiographers are summarized as follows:

- 20% of radiographers (83 out of 422) stated that they had had an incident (accident, near miss or deviation) in the last 5 years.

- A total of 229 deviations were said to have occurred from 409 responses, giving an average of 0.6 deviations per radiographer per 5 years.

- A total of 41 near misses were said to have occurred from 409 responses, giving an average of 0.1 near misses per radiographer per 5 years.

- A total of 16 accidents were said to have occurred from 409 responses, giving an average of 0.04 accidents per radiographer per 5 years.

- Most radiographers (87%, 71 out of 82) who had had incidents in the last 5 years said that they always reported them to their NDT company.

- Less than half the radiographers who had reported incidents believed that their company had, in turn, reported these to the regulatory body; 20% believed the company did not report the incidents; and one-third did not know.

Further details on the radiographers' responses on incidents are given in Appendix I, Section I.2.5, Tables 25–31.

2.3.4.2. NDT companies

The results from the NDT companies are summarized as follows:

- 40% of NDT companies (35 out of 87) stated that they had had an incident (accident, near miss or deviation) in the last 5 years.

- 85% (72 out of 85) reported that they had had no accidents in the last 5 years. A total of 93 accidents were said to have occurred, giving an average of 1.1 accidents per NDT company per 5 years.

- 70% (59 out of 84) reported that they had had no near misses in the last 5 years. A total of 150 near misses were said to have occurred, giving an average of 1.8 near misses per NDT company per 5 years.

- 82% (64 out of 78) reported that they had had no deviations in the last 5 years. A total of 140 deviations were said to have occurred, giving an average of 1.8 deviations per NDT company per 5 years.

- Using data on the number of radiographers in a given NDT company, the following event frequencies were derived:

    - An average of 0.03 accidents per radiographer per 5 years.

    - An average of 0.05 near misses per radiographer per 5 years.

    - An average of 0.05 deviations per radiographer per 5 years.

- Another estimate of the occurrence of incidents in an NDT company was obtained by scaling the results from the radiographer questionnaires on the basis of the number of number of radiographers who completed the questionnaire versus the total number of radiographers for that NDT company, obtained from the NDT company questionnaires This gave:

    - An average of 4.0 accidents per NDT company per 5 years.

    - An average of 6.2 near misses per NDT company per 5 years.

    - An average of 29.3 deviations from normal per NDT company per 5 years.

- With respect to reporting radiation incidents to the regulatory body:

    - All accidents with individual exposures higher than the annual dose limits (11 out of 11) were said to have been reported.

    - 70% of accidents with elevated individual exposures lower than the annual dose limits (57 out of 82) were said to have been reported.

    - 24% of near misses (36 out of 150) were said to have been reported.

    - 15% of other deviations from normal (21 out of 140) were said to have been reported.

    - Very few NDT companies (4%, 1 out of 24) stated that their regulatory body had, in turn, reported the radiation incidents to the IAEA.

- The main sources of information for an NDT company about abnormal individual exposure of its radiographers were:

- From the dosimetry service providers, third party, regulatory body or company, based on the readings from passive dosimeters) – 91% (85 out of 93); and

- Directly from the radiographers via their active dosimeters – 58% (55 out of 95).

- The main means for NDT companies to share information, within the company, about radiation incidents was safety meetings (86%, 82 out of 95). Email was the next most common means (40%, 38 out of 95). Two-thirds of NDT companies (58 out of 91) used two or more methods. Four companies did not select any options, implying that information on incidents was not shared.

- The main means for NDT companies to share information about radiation incidents with other organizations was industry meetings (33%, 31 out of 95). Email was the next most common means (27%, 26 out of 95). 23% (22 out of 95) stated that they did not share information on incidents with other organizations, and a further 14 companies did not select any options. This would suggest that 38% (36 out of 95) do not share information on incidents with other organizations.

Further details on the NDT companies' responses on incidents are given in Appendix II, Section II.4, Tables 90–123.

2.3.4.3. Regulatory bodies

The results from the regulatory bodies are summarized as follows:

- Over 90% of regulatory bodies (55 out of 59) stated that there were requirements for licensees to report radiation incidents in industrial radiography to the regulatory body. The main criteria for reporting were: a lost or stolen source; a stuck source or equipment malfunction with implications for safety; or, an event that caused, or could have caused, significant exposure to workers or the public.

- Over 80% of regulatory bodies provided statistics on the number of notified events in the last 5 years, as follows:

    - Accidents with elevated individual exposures greater than the annual dose limit:

        - 50 regulatory bodies replied:

            - 36 regulatory bodies reported zero notifications.

            - A total of 34 accidents were notified, giving an average of 0.7 such accidents per jurisdiction per 5 years.

    - Accidents with elevated individual exposures less than the annual dose limit:

        - 48 regulatory bodies replied:

            - 29 regulatory bodies reported zero notifications.

        - A total of 181 accidents were notified, giving an average of nearly 4 such accidents per jurisdiction per 5 years.

    - Near misses with the potential for elevated individual exposures greater than the annual dose limit:

        - 46 regulatory bodies replied:

            - 37 regulatory bodies reported zero notifications.

            - A total of 22 near misses were notified, giving an average of 0.5 such events per jurisdiction per 5 years.

    - Near misses with the potential for elevated individual exposures less than the annual dose limit:

        - 46 regulatory bodies replied:

            - 35 regulatory bodies reported zero notifications.

            - A total of 46 near misses were notified, giving an average of 1 such event per jurisdiction per 5 years.

    - Notified deviations from normal operations:

        - 44 regulatory bodies replied:

            - 28 regulatory bodies reported zero notifications.

            - A total of 181 deviations were notified, giving an average of 4.1 such events per jurisdiction per 5 years.

- Two-thirds of regulatory bodies (40 out of 58) stated that they maintain a radiation incident database for their jurisdiction. Of these:

    - About 70% (23 out of 34) analyse the database regularly to determine if there are common factors in the incidents.

    - Two-thirds (23 out of 35) stated that they used the INES system to classify the severity of incidents.

- Only about one-half of regulatory bodies (27 out of 55) stated that they have an established system for sharing lessons learned from reported incidents. Of these, almost all (24 out of 27) disseminated information to the operating NDT companies in their jurisdiction, but fewer than half (10 out of 27) disseminated information to other regulatory bodies.

    - From the 17 regulatory bodies providing data on the number of disseminations, there were a total of 18 instances of disseminating information to NDT companies in the last 5 years, giving an average of approximately 1 action of dissemination per jurisdiction per 5 years.

- One regulatory body reported a high number (86) of disseminations to other regulatory bodies over the last 5 years. The next highest number was 5.

- About 30% of regulatory bodies (16 out of 50) stated that they had reported an industrial radiography incident to the IAEA in the last 5 years.

Further details on the regulatory bodies' responses on incidents are given in Appendix III, Section III.4, Tables 245–261.

2.3.5. Systems and procedures to ensure protection and safety in industrial radiography

2.3.5.1. Safety of the radiographer

The results from the individual radiographers are summarized as follows:

- Nearly 90% of radiographers (373 out of 418) stated that they always check for the presence of the source in the exposure device before taking the device from the store, and 95% (396 out of 418) always check after the NDT test.

- 80% of radiographers (338 out of 418) stated that they always use collimators when performing gamma radiography. A further 18% (77 out of 418) stated that they sometimes use collimators. Only 3 out of 418 said they never used collimators.

- Almost one-half of radiographers (181 out of 377) stated that they always use diaphragms/collimators when performing X ray radiography. A further 35% (133 out of 377) stated that they sometimes use diaphragms/collimators. About 10% stated that they never use diaphragms/collimators.

- 77% of radiographers (320 out of 416) stated that they discussed radiation protection issues or their occupational doses with their RPO, and the mean number of discussions per year was 6. 20% of radiographers (90 out of 416) stated that they did not have such discussions.

Further details on the radiographers' responses are given in Appendix I, Section I.2.4, Tables 23–24, Section I.2.7, Tables 34–35, and Section I.2.9, Tables 51–52.

The results from the NDT companies are summarized as follows:

- All NDT companies stated that they provide their industrial radiographers with at least one form of dosimeter. 88% (84 out of 95) of companies stated that they provide their industrial radiographers with passive dosimeters, and 93% (82 out of 95) that they provide active dosimeters. 76% (72 out of 95) of companies stated that they provide both forms.

- Of those 82 NDT companies providing active dosimeters, the percentage that provided active dosimeters with the following features were:

    - Audible alarm – 85% (70 out of 82);

- Visual alarm – 52% (43 out of 82);
- Vibrating alarm – 5% (4 out of 82).

- All NDT companies stated that they keep records of occupational doses received by their radiographers. Almost all companies (90 out of 93) stated that they inform their radiographers of their personal doses.

- 62% of NDT companies (58 out of 94) stated that they have established investigation levels for personal doses. A larger percentage (82%, 72 out of 88) stated that the regulatory body has established investigation levels for personal doses.
    - For those NDT companies that had an investigation level, 79 gave data on the number of investigations in the last 5 years. Nearly 50% (37 out of 79) stated that they had performed no investigations. A total of just over 750 investigations were said to have taken place, giving an average of nearly 10 investigations per NDT company per 5 years. This corresponds to an average of about 0.2 investigations per radiographer per 5 years.

- A high percentage of NDT companies (91%, 86 out of 94) stated that they provided survey meters.

- The majority of NDT companies (68%, 64 out of 94) stated that they provided area monitors. Most area monitors had visual alarms (46 out of 55) and audible alarms (49 out of 60).

- Almost all NDT companies (93%, 78 out of 84) stated that they require their radiographers to use collimators with gamma radiography. This is a little higher than the radiographer responses for the same companies, where about 80% said they always used collimators and about 20% used them sometimes.

- The majority of NDT companies (78%, 61 out of 79) stated that they require their radiographers to use collimators with X ray radiography. Radiographer responses for 45 of these companies indicated that some radiographers in 8 of the companies never used collimators, despite the company requirement.

- Almost all NDT companies (97%, 91 out of 94) stated that they have a RPO or RPE included in their organization. Of these, for the majority (86%, 78 out of 91) the RPO/RPE reported directly to the managing director.

Further details on the NDT companies' responses are given in Appendix II, Section II.5.1, Tables 124–126, Section II.5.2, Tables 127–130, Section II.5.3, Tables 133–134, Section II.5.6, Tables 149–150, and Section II.7.3, Tables 226–227.

The results from the regulatory bodies are summarized as follows:

- Excluding three 'no replies', all regulatory bodies stated that they require industrial radiographers to use passive dosimeters. 80% (45 out of 56) also required industrial radiographers to have active dosimeters.

- Of those regulatory bodies requiring active dosimeters, the following features were required:

- Measurement of integrated dose – 64% (27 out of 42);
- Audible alarm – over 90% (41 out of 44);
- Visual alarm – 63% (25 out of 40);
- Vibrating alarm – 24% (9 out of 38).

- Reporting of monitored doses of industrial radiographers:
  - 80% of the regulatory bodies (44 out of 54) stated that the radiographers had to be informed about their doses, with a median value of 12 times per year;
  - 90% of the regulatory bodies (53 out of 58) stated that the NDT company or employer had to be informed about the industrial radiographer doses, with a median value of 12 times per year;
  - 70% of the regulatory bodies (38 out of 53) stated that the regulatory body had to be informed about the industrial radiographer doses, with a median value of 4 times per year; and
  - 70% of the regulatory bodies (36 out of 49) stated that the national personal dose database had to be informed about the industrial radiographer doses, with a median value of 12 times per year.

- Almost all regulatory bodies (52 out of 55) required the industrial radiographer to always have a functioning and calibrated survey meter with them.

- 90% of regulatory bodies (52 out of 57) stated that they require the NDT company to employ an RPO or RPE. Of these, 80% (40 out of 51) require that the RPO or RPE reports directly to the Managing Director, or equivalent, of the NDT company.

Further details on the regulatory bodies' responses are given in Appendix III, Section III.5.1, Tables 262–276, and Section III.6.4, Tables 324–325.

2.3.5.2. Safety of the public

The results from the NDT companies are summarized as follows:

- 70 NDT companies provided data on the dose rate at which a warning system is required to be set up. The mean dose rate was 13 μSv per hour, with a median of 7.5 μSv per hour and an inter-quartile range of 2.5–20 μSv per hour.

- Rope or ribbon was used in the warning system in the majority of cases (89%, 84 out 94), plus a high usage of signage – 76% (71 out of 94) for passive warning signs and 71% (67 out of 94) for active warning signs.

- 58% of NDT companies (53 out of 91) stated that they had determined the more common causes for unauthorized persons to trespass past the warning system. The most common stated causes were wilful violation (84%) and the warning system not being understood (60%), with incorrect setting up of the warning system also being indicated (20%).

- 72% of NDT companies (67 out of 93) require their radiographers to always announce or warn whenever a radiographic exposure is made. 13% of companies (12 out of 93) stated that they did not require such announcements or warnings. Where an announcement or warning was required, a visible alarm (such as flashing lights) was the most common method (86%), followed by an announcement via a public address system (51%), and an audible alarm (44%). Often, more than one method was used.

- When NDT companies are providing radiography services in an industrial plant:

    - The majority of NDT companies (71%, 60 out of 84) reported that the client was always providing information about other interfering activities on site.

    - Less than half the NDT companies (45%, 37 out of 83) stated that the client always provided a plan of the installation. On the other hand, few companies (7%, 6 out of 83) stated that they were never provided with plans.

    - About half the companies (53%, 45 out of 85) said that the client always had a 'permit to work' system.

    - No NDT company reported that their clients never inform other workers about the radiography to be performed.

    - Just over half the companies (54%) stated that their clients always inform other workers about the purpose and method of the warning system, the meaning of alarm signals, and the risks of ionizing radiation. Conversely, very few (5%) companies reported that the clients never inform other workers on these matters.

Further details on the NDT companies' responses are given in Appendix II, Section II.5.4, Tables 135–141, and Section II.5.5, Tables 142–148.

The results from the regulatory bodies are summarized as follows:

- Only about 40% of regulatory bodies (22 out of 58) required advance notification about individual on-site industrial radiography jobs. Of those:

    - From the 17 regulatory bodies providing data on the number of hours of advance notification, the average advance notification required was 48 hours, while the median value was 24 hours.

- Almost all regulatory bodies (56 out of 58) required the use of a warning system to prevent entry to the radiography site. Of these, 80% of regulatory bodies (47 out of 56) stated that they had an official standard procedure for such a warning system.

    - Such standard procedures typically required barriers (46 out of 46); warning signs (47 out of 47); and, flashing lights (31 out of 43).

- 43 regulatory bodies provided data on the maximum dose rate allowed at the barrier. The average was 30 μSv/hour, and the median value was 10 μSv/hour.

- Only about 40% of regulatory bodies (24 out of 58) require the client (who is receiving the on-site radiography services) to inform the NDT company about conditions at the site that might affect safety of other workers on site. Of these:
    - 70% of regulatory bodies (17 out of 23) require the client to provide the NDT company with site plans; and
    - All regulatory bodies (22 out of 22) require the client to provide the NDT company with information about other worker activities, occurring at the same time and in the vicinity of where the radiography will occur.
- Almost half of the regulatory bodies (28 out of 57) require that there is a qualified radiation protection officer or radiation protection expert on the work site during on-site radiography.

Further details on the regulatory bodies' responses are given in Appendix III, Section III.5.2, Tables 277–289.

2.3.5.3. Safety of sources and exposure devices

The results from the NDT companies are summarized as follows:

- 78 NDT companies provided data on the interval between preventative maintenance for exposure devices in gamma radiography — the mean and median interval between maintenance was 8 and 6 months, respectively. Two NDT companies reported that preventative maintenance was not performed.
- The auxiliary equipment reported to be included in the preventative maintenance was:
    - Control cable (100%, 81 out of 81);
    - Guide tube (100%, 81 out of 81);
    - Crank (95%, 77 out of 81);
    - Collimator (69%, 56 out of 81).
- Preventative maintenance was performed by various combinations of the NDT company itself, the device manufacturer and a third party service provider. The NDT company was involved in 72% of the responses (60 out of 83), 41% of responses for the device manufacturer, and 49% for a third party service provider.
- 67 NDT companies provided data on the interval between preventative maintenance for X ray equipment used in industrial radiography — the mean and median interval between maintenance was 8 and 6 months, respectively. One NDT company reported that it did not perform preventative maintenance.
- The auxiliary equipment reported to be included in the preventative maintenance was:
    - Cables (88%, 65 out of 74);
    - Control panel (97%, 72 out of 74);

- Diaphragm or collimator (72%, 53 out of 74);
- X ray output (78%, 57 out of 73);
- Leakage radiation (78%, 57 out of 73).

- The preventative maintenance was performed by various combinations of the NDT company itself, the device manufacturer and a third party service provider. The NDT company was involved in 67% of the responses (50 out of 75), 32% of responses for the device manufacturer, and 55% for the third party service provider.

Further details on the NDT companies' responses are given in Appendix II, Section II.5.7, Tables 151–157, and Section II.5.8, Tables 158–165.

The results from the regulatory bodies are summarized as follows:

- 80% of regulatory bodies (43 out of 55) stated that they require any source used for industrial radiography purposes to meet specified standards. 31 regulatory bodies provided details on what these standards were:
  - 60% (19 out of 31) named specific ISO standards, including ISO2919:1999 RP — Sealed radioactive sources — general requirements; ISO9978:1992 RP — Sealed radioactive sources — leakage test methods; or ISO3999:2004 — Radiation protection — Apparatus for industrial gamma radiography — Specifications for performance, design and tests.
  - 26% (8 out of 31) invoked unspecified national regulations, standards or norms.
  - 19% (6 out of 31) invoked unspecified international standards.
- 80% of regulatory bodies (43 out of 55) stated that they require any exposure device used for industrial radiography purposes to meet specified standards. 33 regulatory bodies provided details on what these standards were:
  - 48% (16 out of 33) named specific ISO standards, including ISO2919:1999 RP — Sealed radioactive sources — general requirements; ISO9978:1992 RP — Sealed radioactive sources — leakage test methods; or ISO3999:2004 — Radiation protection — Apparatus for industrial gamma radiography — Specifications for performance, design and tests.
  - 30% (10 out 33) invoked unspecified national regulations, standards or norms.
  - 24% (8 out 33) invoked unspecified international standards.
- 80% of regulatory bodies (45 out of 55) require that the source and the exposure device are subject to periodic inspections to verify compliance with required standards. 35 regulatory bodies provided data on how often such inspections must occur — the average and median interval between inspections was 12 months. Of those regulatory bodies requiring inspections:
  - 90% (39 out of 43) stated that accessories are included;

- 90% (37 out of 40) permit the manufacturer or manufacturer's agent to perform such services;
- 70% (24 out of 36) permit the NDT company to perform such services;
- Over 70% (25 out of 34) permit an approved third party to perform such services.

- 65% of regulatory bodies (36 out of 55) stated that they require any X ray generator used for industrial radiography purposes to meet specified standards. 27 regulatory bodies provided details on what these standards were:
  - 50% (13 out of 27) invoked national regulations, standards or norms;
  - 60% (16 out of 27) invoked international standards.

- 70% of regulatory bodies (41 out of 56) require that the X ray equipment is subject to periodic inspections to verify compliance with required standards. 32 regulatory bodies provided data on how often such inspections must occur — the median interval between inspections was 12 months. Of those regulatory bodies requiring inspections:
  - 90% (33 out of 36) stated that accessories are included;
  - 90% (32 out of 35) permit the manufacturer or manufacturer's agent to perform such services;
  - 75% (23 out of 30) permit the NDT company to perform such services;
  - 80% (25 out of 31) permit an approved third party to perform such services.

- Almost all regulatory bodies (55 out of 56) specify requirements for on-site storage of sources.

- Almost all regulatory bodies (53 out of 57) require the licensee to conduct periodic documented checks of sources to confirm that they are in their assigned locations and are secure.

Further details on the regulatory bodies' responses are given in Appendix III, Section III.5.3, Tables 290–309.

2.3.5.4. Compliance inspections

The results from the NDT companies are summarized as follows:

- 66% of NDT companies (63 out of 95) reported that their Radiation Protection Programme (RPP) was approved by the company's managing director or chief executive officer; 62% (59 out of 95) reported approval by the company's RPO; and 61% (57 out of 93) reported approval by the regulatory body. 31% reported that all three parties approved their RPP, while no NDT company reported that their RPP was approved by none of the parties.

- Almost all NDT companies (96%, 89 out of 93) reported that they performed their own compliance inspections of their radiographers. Of these:
    - 61% reported that they performed planned (announced) compliance inspections;
    - 77% reported that they performed unplanned (unannounced) compliance inspections;
    - 42% reported that they performed both sorts of inspections;
    - Most of the compliance inspections (89%, 76 out of 85) involved the RPO. Some management team presence was reported for 42% of NDT companies;
    - From the data of 78 responses, the mean and median number of times a radiographer would be inspected by the company in a year were 4 and 2, respectively;
    - The following summarizes the percentage of company inspections that addressed:
        - Proper wearing of passive individual dosimeters – 95%;
        - Proper wearing and use of active individual dosimeters – 93%;
        - Proper use of survey meters – 95%;
        - Proper use of collimators – 90%;
        - Proper warning system at the work site – 93%;
        - Dose rate at the boundary of the work site within the limits set – 92%;
        - Proper use of alarm systems – 86%;
        - Proper training and qualifications of radiographers – 91%;
        - Operator knowledge of procedures – 88%;
        - Pre-operation specific equipment checks – 82%;
        - Equipment condition – 85%;
        - Emergency preparedness – 74%.
    - The five most common shortcomings were reported as:
        - No proper use of collimators;
        - Dose rate at the boundary of the work site not within the limits set;
        - No proper use of survey meters;

- No pre-operation specific equipment checks being performed;
- Poor operator knowledge of procedures.

- 66% of NDT companies (60 out of 91) reported that the regulatory body performed planned (announced) compliance inspections of the company's radiographers on the work site.
    - From the 56 responses with data, the reported mean and median number of times a year that a company radiographer would undergo a planned regulatory body inspection were 2 and 1, respectively.
- 64% of NDT companies (58 out of 91) reported that the regulatory body performed unplanned (unannounced) compliance inspections of the company's radiographers on the work site.
    - From the 51 responses with data, the reported mean and median number of times a year that a company radiographer would undergo an unplanned regulatory body inspection were 2 and 1, respectively.
- 87% of NDT companies (81 out of 93) reported that the regulatory body performed some form of compliance inspections of the company's radiographers on the work site.
    - From the 74 responses with data, the calculated mean number of times that a company radiographer would undergo a regulatory body inspection was nearly 3 times a year.
- 40% of NDT companies (37 out of 93) reported that the regulatory body performed both planned (announced) and unplanned (unannounced) compliance inspections of the company's radiographers on the work site.
    - From the 33 responses with data, the calculated mean number of times that a company radiographer would undergo a regulatory body inspection was approximately 4 times a year, with 2 being planned and 2 being unplanned.
- 13% of NDT companies (12 out of 93) reported that the regulatory body performed neither planned or unplanned (unannounced) compliance inspections of the company's radiographers on the work site.

Further details on the NDT companies' responses are given in Appendix II, Section II.5.9, Tables 166–169, Section II.5.10, Tables 170–195, and Section II.5.11, Tables 196–201.

The results from the regulatory bodies are summarized as follows:

- Over 90% of regulatory bodies (54 out of 58) stated that they perform inspections of NDT companies that provide on-site radiography services. Of these, 85% (46 out of 54) perform inspection where on-site radiography is actually taking place. Further, of the inspections:
    - 26% (14 out of 53) are announced only;

- 2% (1 out of 53) are unannounced only; and
- 72% (38 out of 53) are either announced or unannounced.

- From the data of 46 regulatory bodies, the average and the median number of regulatory inspections were both 1 per year. Most regulatory inspections addressed similar elements, including:
  - Wearing of passive dosimeters – 98% (51 out of 52);
  - Wearing of active dosimeters – 90% (46 out of 51);
  - Use of survey meters – 96% (50 out of 52);
  - Use of collimators – 88% (44 out of 50);
  - Use of warning systems to prevent entry to the work site – 98% (51 out of 52);
  - Dose rate at the boundary of the warning system – 90% (47 out of 52);
  - Use of alarm systems – 96% (49 out of 51);
  - Training and qualifications of radiographers – 100% (52 out of 52);
  - Operator knowledge of procedures – 96% (47 out of 49);
  - Pre-operation equipment checks – 86% (42 out of 49);
  - Equipment condition – 98% (49 out of 50);
  - Emergency preparedness – 96% (47 out of 49).
- Based on the responses from 54 regulatory bodies, the 5 most common shortcomings were:
  - 1st – No proper use of survey meters;
  - 2nd – No proper warning system to prevent entry to the work site;
  - 3rd – Poor emergency preparedness;
  - 4th – No proper use of alarm systems;
  - 5th – Dose rate at the boundary for the work site not within limits set.

Further details on the regulatory bodies' responses are given in Appendix III, Section III.6.1, Tables 310–313, Section III.6.2, Tables 314–317, and Section III.6.3, Tables 318–323.

2.3.5.5. Emergency preparedness and response

The results from the individual industrial radiographers are summarized as follows:

- Over 90% of radiographers (385 out of 412) stated that the NDT company they worked for had an emergency plan for site radiography. Of these, almost 90% (338 out of 379) said that they had received training for the roles and responsibilities of radiographers in that emergency plan. For further details see Appendix I, Section I.2.6, Tables 32–33.

The results from the NDT companies are summarized as follows:

- Almost all NDT companies (95%, 90 out of 95) stated that they had an emergency plan and procedures for responding to incidents during the performance of site radiography. Of the four 'no' responses, all were X ray only NDT companies.

- The emergency plan is communicated and discussed with:

    - Company radiographers – over 90% of NDT companies (82 out of 88);

    - Company clients – less than half of NDT companies (42 out of 85);

    - The regulatory body – 82% of NDT companies (69 out of 84);

    - Other emergency response authorities – 44% of NDT companies (36 out of 82).

- All responding NDT companies communicated and discussed their emergency plan with at least one of the above parties. 26 NDT companies stated that they communicated and discussed their emergency plan with all of the above parties.

- 82% of NDT companies (78 out of 95) stated that they provided specific training to their radiographers on emergency preparedness and response. This specific training included:

    - Explanation of emergency procedures – effectively all, with 77 out of 78, and one 'no reply';

    - Practical exercises on containment of the situation – 90%, 69 out of 77;

    - Practical exercises on source recovery – 73%, 53 out of 73.

- The 16 'no' answers with respect to specific training on emergency preparedness and response were dominated by 13 from Europe. It is likely that these responses reflect the practice and requirements to use specialist persons in emergency roles, and hence training radiographers for this role is not considered appropriate.

- 91% of NDT companies (85 out of 93) stated that they have emergency equipment for site radiography. Emergency equipment included:

    - Long tongs – 89% of NDT companies (74 out of 83);

    - Shielding material – 98% of NDT companies (80 out of 82);

    - Emergency or rescue container – 79% of NDT companies (64 out of 81);

- Other equipment included protective clothing (6 responses), cutting equipment (6), additional survey meters (long) and dosimeters (4), fire extinguishers (2), first aid kit (1), and toolbox (1).

- 92% of NDT companies (77 out of 84) stated that their radiographers have access to emergency equipment.

- In reply to the questions on responsibilities at the various stages of an emergency, the following are summarized:

  - Responsibility for containment of the situation:

    - The radiographer and the RPO for most NDT companies (78%, 68 out of 89). There were no responses where the radiographer or the RPO were not involved.

  - Responsibility for planning and rehearsing the recovery:

    - Primarily the RPO (87%, 75 out of 86), with a supporting role of the radiographer (44%, 38 out of 86). There were 4 responses where the radiographer or the RPO were not involved.

  - Responsibility for recovery of the situation:

    - Primarily the RPO (77%, 67 out of 87), with a supporting role of the radiographer (46%, 40 out of 87). There were 3 responses where the radiographer or the RPO were not involved.

  - Responsibility for investigating and reporting:

    - Primarily the RPO (89%, 77 out of 87), with a supporting role of the radiographer (34%, 30 out of 87). There were 3 responses where the radiographer or the RPO were not involved.

- Just over half of NDT companies (56%, 49 out of 87) stated that they hold emergency exercises to test the critical components of the company's emergency plan.

  - From those that responded that they do hold exercises, the mean number of exercises per year was 2 and the median number was 1.

- Nearly two-thirds of NDT companies (63%, 54 out of 86) stated that they undertake periodic formal reviews of the company's emergency plan.

  - From those that responded that they do undertake reviews, the mean and median number of reviews per year was 1.

Further details on the NDT companies' responses are given in Appendix II, Section II.6, Tables 202–218.

The results from the regulatory bodies are summarized as follows:

- Almost all regulatory bodies (57 out of 58) stated that they require NDT companies to have an emergency plan. Three-quarters of the regulatory bodies (43 out of 57) require the emergency plan to specify requirements for training and exercises. 80% of regulatory bodies (43 out of 55) stated that they approve an NDT company's emergency plan.

- Three-quarters of the regulatory bodies (43 out of 57) require licensees to have emergency equipment.

- 60% of regulatory bodies (35 out of 57) stated that they have resources to assist licensees in recovering from emergencies.

- 90% of regulatory bodies (52 out of 57) stated that they check the emergency plan and equipment during periodic inspections or at licence renewal.

Further details on the regulatory bodies' responses are given in Appendix III, Section III.7, Tables 326 – 331.

2.3.6. Individual monitoring

2.3.6.1. Individual industrial radiographers

The results from the individual industrial radiographers are summarized as follows:

- Over 90% of radiographers (387 out of 423) stated that they knew what occupational doses they received. The mean number of times per year that the radiographer was informed about their dose was 11 times, and the median number was 12 times. This is consistent with 1 month or 4 weeks being the most commonly reported monitoring periods (73%). Further details are given in Appendix I, Section I.2.8, Tables 36–38.

- Over 200 radiographers gave a value for their annual occupational effective dose in 2009:

    - The average was dose for 2009 was 3.4 mSv, with a reported maximum annual effective dose of 30 mSv.

    - While the majority of radiographers (76%) stated that they received an annual effective dose of less than 5 mSv in 2009, nearly one-quarter received a dose between 5 and 20 mSv, and a small percentage (2%) received a dose greater than 20 mSv.

    - Further details are given in Appendix I, Section I.2.8, Table 39, Section I.3.1, Tables 53–54, and Figure 6.

- Almost 200 radiographers gave a value for their maximum dose for a monitoring period in 2009. Results were normalized to a 1 month monitoring period:

    - Nearly 70% of radiographers (122 out of 181) had a maximum monthly dose in 2009 of less than 1 mSv. The mean maximum monthly dose was 1.4 mSv and the median 0.5 mSv.

- One radiographer had a maximum monthly dose in 2009 exceeding 20 mSv.
- 4% of radiographers (7 out of 181) had a maximum monthly dose in 2009 exceeding 5 mSv.
- On average, approximately one-third of the annual dose is received in the month with the highest dose.
- Further details are given in Appendix I, Section I.2.8, Table 40, Section I.3.2, Tables 55–56, and Figures 7 and 8.

- Based on data from 141 radiographers who provided both annual doses and workloads, the estimate (at the 95% level) of mean occupational dose per exposure was 4.8 ± 2.3 μSv. If data for radiographers with very low workloads are excluded (less than 100 exposures per year), 129 data points remained, giving an estimate of mean occupational dose per exposure of 2.9 ± 1.2 μSv. Further details are given in Appendix I, Section I.3.3, Table 57–58.

- There was no statistically significant difference between the mean occupational dose per exposure for those radiographers who worked with gamma sources only and those who worked with X ray sources only. Further details are given in Appendix I, Section I.3.4.1, Table 59 and Figures 10-11.

- For those radiographers who worked with Ir-192 sources in 2009, there was no strong correlation of annual occupational dose with source activity, and no strong correlation of occupational dose per exposure with source activity. However, in both cases, the correlation was stronger for radiographers who worked with Ir-192 sources only compared with those radiographers who worked with other sources as well as Ir-192. Further details are given in Appendix I, Section I.3.4.2, Figures 12-15.

- There was no statistically significant difference between the mean occupational dose per exposure for those radiographers who always used collimators when working with gamma sources compared with those who only sometimes used collimators. Further details are given in Appendix I, Section I.3.4.3, Table 60 and Figures 16-17.

- There was no statistically significant difference between the mean occupational dose per exposure for those radiographers who always used diaphragms/collimators when working with X ray sources compared with those who never used diaphragms/collimators. Further details are given in Appendix I, Section I.3.4.4, Table 61 and Figures 18-19.

- There was no statistically significant difference between the mean occupational dose per exposure for radiographers with level 3 NDT training compared with level 2 or level 1 radiographers. Further details are given in Appendix I, Section I.3.4.5, Tables 62-63 and Figures 20-21.

- There was no correlation between the annual occupational effective dose in 2009 and the total number of events (accidents, near misses and deviations), or each separately. Similarly, there was no correlation for the highest monthly occupational dose, or for the occupational dose per exposure. Further details are given in Appendix I, Section I.3.4.6, Tables 64-65 and Figures 22-23.

- There was no statistically significant difference between the estimates of mean annual effective dose for the radiographers who had had events in the last 5 years compared with those radiographers who had not had events. Similarly for the estimates of mean occupational dose per exposure. Further details are given in Appendix I, Section I.3.4.6, Table 66 and Figures 24-25.

2.3.6.2. NDT companies

76 NDT companies provided banded annual dose data for a total of 3375 industrial radiographers for the year 2009. Over half (58%) had an estimated annual effective dose less than the 1 mSv. A small percentage (0.3%) had an estimated annual effective dose greater than or equal to the dose limit of 20 mSv. Further details are given in Appendix II, Section II.5.2, Tables 131-132 and Figure 26.

2.3.6.3. Regulatory bodies

The results from the regulatory bodies are summarized as follows:

- 60% of regulatory bodies (34 out of 55) stated that they have direct access to a national or state database of individual doses for industrial radiographers and other workers involved in NDT.

- 33 regulatory bodies were able to supply annual dose data for industrial radiographers for the year 2009:

    - The average annual effective dose for nearly 18,000 monitored industrial radiographers, from 33 countries, was 2.9 mSv, with a reported maximum annual effective dose of 158 mSv.

    - While the vast majority of industrial radiographers (86%) received an annual effective dose of less than 5 mSv in 2009, nearly 350 persons (2%) received a dose greater than 20 mSv, and nearly 50 persons (0.3%) received a dose greater than 50 mSv.

    - The average annual effective dose for nearly 5,000 monitored 'other NDT workers', from 10 countries, was 0.6 mSv, with a reported maximum annual effective dose of 91 mSv.

    - 99% of 'other NDT workers' received an annual effective dose of less than 5 mSv in 2009.

    - From the distribution of country-average annual effective doses:

        - The mean country-average effective dose for industrial radiographers was 2.2±0.8 mSv for 2009; and

        - The mean country-average effective dose for 'other NDT workers' was 1.2±0.8 mSv for 2009.

- 21 regulatory bodies were able to supply data on the maximum monthly dose for industrial radiographers for the year 2009:

- 90% of industrial radiographers (8201 out of 9144) had a maximum monthly dose in 2009 of less than 1 mSv.
- 3 radiographers had a maximum monthly dose in 2009 exceeding 50 mSv.
- 2% of radiographers (187 out of 9144) had a maximum monthly dose in 2009 exceeding 5 mSv.
- 98% of 'other NDT workers' (3572 out of 3642) had a maximum monthly dose in 2009 of less than 1 mSv.

- About one-half of regulatory bodies (17 out of 30) stated that they perform trend analysis of the occupational doses in industrial radiography. All of these regulatory bodies stated that they use the results of the analyses to improve radiation protection in industrial radiography.

Further details on the responses from the regulatory bodies are given in Appendix III, Section III.8, Tables 332 – 347, and Figures 27 - 30.

2.4. DISCUSSION

As noted above in Section 2.3.1 on caveats, caution must be exercised in drawing conclusions from the survey results. Nevertheless, some comments and discussion follow on particular topics. Further, having the three questionnaires with responses from the three different sources – radiographers, NDT companies and regulatory bodies – provides different perspectives on the various topics, and allows comparisons to be made. Additional comments appear in the Appendices I-III as notes to some of the tables and figures.

There are other aspects that affect radiation safety in industrial radiography, which the results of the survey are likely to have glossed over. The first is that while an NDT company may have a manual with a comprehensive set of safe operating procedures, this does not necessarily translate into the use of those procedures in actual practice in the field. Some hint of the extent of this problem is evident in the comparison of results for company responses with those for the radiographers – see Section 2.4.3.1 below, for example.

A second aspect is that clients can bring undue pressure upon the NDT company, and hence the industrial radiographers, to complete a given task in a constrained period of time or a set of adverse conditions. A third related aspect is that an NDT company may be operating on a very narrow profit margin in order to secure a given contract. In both these cases, corners are likely to be cut, and radiation protection and safety likely to be compromised. The effect of such issues is unlikely to have fully emerged in the results of the survey.

2.4.1. Radiation protection training and qualifications of industrial radiographers

The need for radiation protection training in industrial radiography appears to be well accepted and established. On the one hand, the regulatory bodies almost universally stated that they require radiation protection training for radiographers, and on the other hand almost all the NDT companies provided or facilitated initial radiation protection training. The result was that the radiographer responses indicated a high prevalence of radiation protection training, with only 8 responding radiographers (2%) stating that they had not had radiation protection training. It should have been zero radiographers having had no radiation protection training, but nonetheless the result is very much towards the desired situation.

Most regulatory bodies (90%) required the radiation protection training to include both theory and practical. Data from the NDT companies showed that almost all (96%) gave initial theoretical training in radiation protection, with a mean of nearly 40 hours, but a lower number (82%) gave initial practical training in radiation protection, with a mean of 30 hours. This appears to be in addition to any radiation protection training received as part of the NDT training, as indicated by the radiographer responses where the greater majority (85%) stated that they had received radiation protection training separate to the NDT training.

Refresher training was less well established, with only 70% of regulatory bodies stating that they required refresher training in radiation protection for persons performing on-site radiography. Almost 20% of NDT companies reported that they did not provide or facilitate refresher theoretical training in radiation protection, and a larger percentage (40%) reported that they did not provide or facilitate refresher practical training in radiation protection. Clearly, there is scope for improvement.

The question of specific training for emergency situations is an interesting one. The majority of radiographers (89%) reported that procedures for emergencies were included in their radiation protection training. However, only two-thirds said that the training included practical exercises for creating a safe situation until the source is able to be recovered, and just over half said that the training included practical exercises for source recovery. Three-quarters of the radiographers stated that they were not allowed to perform a source recovery on their own without first contacting a specialized source recovery person. Regardless of the authority of radiographers to actually perform source recovery, given the likelihood of emergencies and the associated very real health hazards it should seem essential that all radiographers are well trained with respect to procedures for emergencies.

The NDT companies were asked about training for emergencies in two parts of their questionnaire. In the section on radiation protection education and training (in Question1c) almost all (90 out of 92) stated that their training included emergency procedures. However, in the section on emergency preparedness and response (question 24), the lower number of 78 stated that they provided specific training to their radiographers on emergency preparedness and response. Of twelve who had said ‘yes’ to Question 1c(i), eleven then said ‘no’ to question 24, and one said they did not know. Perhaps there were perceived differences in the two questions, and it was noted that the NDT companies that said ‘no’ to Question 24 were predominantly from Europe and likely reflected the practice and requirements to use specialist persons in emergency roles. Perhaps more reassuringly, only two NDT companies said ‘no’ to both questions, although again this should arguably have been zero.

The influence of different country and regional approaches to dealing with emergencies was further evident in the results for the practical training on containment of the situation and creating a safe situation and on source recovery. In both areas of training, the percentages for Europe, North America and Africa were lower than for Asia-Pacific and Latin America.

From the regulatory perspective, the regulatory body responses showed that about 70% require the radiation protection training to include practical exercises for creating a safe situation in an emergency until the source is able to be recovered, with a lower percentage (about 60%) requiring practical exercises for source recovery.

It would seem essential that all radiographers who perform on-site radiography be trained in emergency procedures and understand their role and what specific steps they are required to

be involved in to create a safe situation, regardless of who will ultimately perform the source recovery.

The concerns expressed here are perhaps echoed in the radiographer responses to the question on 'do you feel sufficiently well qualified and trained to be able to work safely and reliably?', to which less than 2% of radiographers replied 'no', but about 10% replied that they did not feel well prepared for an emergency situation.

It was perhaps surprising that, while almost all regulatory bodies (57 out of 59) stated that any person wishing to act as an RPO for a company that performs on-site radiography must have had radiation protection training to an acceptable level, only 70% (39 out of 57) thought that the acceptable level was higher than that for a radiographer. It would seem essential that in an industry with a track record of accidents and incidents that the RPO really needs to have specialist expertise in radiation protection. This would, therefore, seem to be an area for improvement.

2.4.2. Incidents (deviations, near misses and accidents)

Accidents, near misses and deviations are widely recognized as being a characteristic of industrial radiography [2], and the results of this survey provide such confirmation — they do occur. It is likely that the reported values in the survey are an underestimate, especially with regard to near misses and deviations.

Rates of occurrence of accidents, near-misses and deviations were reported by both the radiographers and the NDT companies. Tables 1 and 2 compare the derived rates of incidence from the two sources for each of accidents, near misses and deviations. The estimates of rates of incidence for radiographers were obtained directly from the radiographer responses and derived from the NDT company responses by scaling the company incidence by the number of radiographers in that company. Similarly, the estimates of rates of incidence for NDT companies were obtained directly from the NDT company responses and derived from the radiographer responses by scaling the radiographer incidence by the number of radiographers in that company.

TABLE 1. ESTIMATES OF THE INCIDENCE RATES OF ACCIDENTS, NEAR MISSES AND DEVIATIONS PER RADIOGRAPHER PER 5 YEARS, ESTIMATED FROM THE RADIOGRAPHER RESPONSES AND THE NDT COMPANY RESPONSES

	Radiographer data	**NDT company data**
Incidence of:	Per radiographer per 5 years	Per radiographer per 5 years
Accidents	0.04	0.03
Near misses	0.1	0.05
Deviations	0.6	0.05

TABLE 2. ESTIMATES OF THE INCIDENCE RATES OF ACCIDENTS, NEAR MISSES AND DEVIATIONS PER NDT COMPANY PER 5 YEARS, ESTIMATED FROM THE RADIOGRAPHER RESPONSES AND THE NDT COMPANY RESPONSES

	Radiographer data	**NDT company data**
Incidence of:	Per NDT company per 5 years	Per NDT company per 5 years
Accidents	4.0	1.1
Near misses	6.2	1.8
Deviations	29.3	1.8

While there are uncertainties associated with the data, in each case the estimate from the NDT company data was less than the corresponding estimate from the radiographer data, especially for near misses and deviations. This would suggest that there is a knowledge gap between what occurs in the field versus what is known or acknowledged back at headquarters. There may be reluctance for a radiographer to report an incident for fear of repercussions, or there may be reluctance for NDT companies to acknowledge that incidents are happening in their company. A safety culture needs to be promoted in all NDT companies, whereby reporting of incidents is not only encouraged but is also seen by all as adding value to radiation safety by providing the opportunity to learn and to improve.

Sharing information about radiation incidents is a well-recognized means for minimizing the likelihood of similar incidents elsewhere, but the level of dissemination appears to be less than desirable. While almost all NDT companies had one or more means for doing this within their companies, there was a sizeable proportion (nearly 40%) that did not appear to share information on incidents with other organizations.

Almost all regulatory bodies reported that they had established criteria for when it was a requirement to report an incident to the regulatory body. For the more serious accidents, reporting to the regulatory body by the NDT company appeared to be well implemented — 100% for accidents with individual exposures higher than the annual dose limits, and 70% for accidents with elevated individual exposures, but lower than the dose limits. Statistics from the regulatory body perspective gave an accident incidence of nearly 5 accidents per jurisdiction per 5 years. As with the radiographers above, there may be reticence for an NDT company to report an incident for fear of regulatory actions. Again, the more incidents that are reported, the greater the scope for learning and for dissemination of information to minimize the likelihood of recurrences.

Only two-thirds of regulatory bodies stated that they maintain a radiation incident database for their jurisdiction, resulting in slightly less than half of the regulatory bodies analyzing data regularly to determine if there are common factors in the incidents. Again, only about one-half of the regulatory bodies reported having an established system for sharing lessons learned from reported incidents, reiterating the comment above on poor dissemination.

Means for minimizing the likelihood of incidents remains a priority in industrial radiography, and the survey results indicate there is room for improvement in reporting incidents from the field to the company, and from the company to the regulatory body. For the latter, more

regulatory bodies should consider establishing an incident database which would then facilitate the dissemination of lessons learned.

2.4.3. Systems and procedures to ensure protection and safety in industrial radiography

2.4.3.1. Safety of the radiographer

Safety of the radiographer is ensured through having good work and radiation protection practices and confirming this with appropriate dosimetry and monitoring.

Most, but not all, radiographers reported checking for the presence of the source in the exposure device before taking the device from the store, and checking after completing the NDT exposure. Knowledge about where the source is at all times is crucial in preventing accidents, and cannot be overstressed. All radiographers should be routinely performing these checks each and every time.

Collimators are used to reduce the radiation beam in some directions. They should be used whenever possible, to reduce radiation levels and subsequent occupational doses. A very small percentage of radiographers (< 1%) said they never used collimators when performing gamma radiography, but about 10% said they never used diaphragms/collimators for X ray radiography. From the company perspective, over 90% said they required collimators to be used for gamma radiography and this can be compared with the radiographers from the same companies of whom only 80% said that they always used collimators. For X ray radiography, almost 80% of NDT companies stated that they required the use of diaphragms/collimators, but the radiographer responses for 8 out of 45 of these companies suggested that some radiographers were not using diaphragms/collimators despite the company requirement. Clearly, there is room for improved practice.

The survey meter plays an important radiation safety role in industrial radiography. Almost all regulatory bodies (95%) stated that they require an industrial radiographer to always have a functioning and calibrated survey meter with them. Almost the same percentage of NDT companies (91%) stated that they provide survey meters. Unfortunately, the radiographer questionnaire did not ask about the presence and use of survey meters. Perhaps an estimate of use is given by the percentage of radiographers that check for the presence of the source in the exposure device after performing NDT exposures — namely, 95%. While all these percentages are high, each should really be 100%.

The RPO has a role to play in promoting good practice in the field. Most (90%), but not all, regulatory bodies stated that they require an NDT company to employ an RPO or RPE, and almost all NDT companies (97%) stated that they have an RPO or RPE in their organization. However presence in the field is another issue. About one-half of the regulatory bodies required an RPO to be present on the work site during on-site radiography. This aligns well with about 55% of radiographers reporting that an RPO or RPE was on site during on-site radiography. This implies that in almost half of the companies and for almost half the radiographers, on-site radiography is being performed without the benefit of radiation protection knowledge of the RPO. It was also less than satisfactory that 20% of radiographers reported that they did not have regular discussions with their RPO on radiation protection issues or their occupational doses.

All regulatory bodies stated that they required radiographers to use passive dosimeters. While about 80% also required the use of active dosimeters, this means that there were about 20% of

regulatory bodies who had no expectation that radiographers need to have active dosimeters with alarm functions. Most active dosimeters had audible alarms, but fewer had visual or vibrating alarms. Using active dosimeters that utilize three senses rather than just one would seem to provide additional radiation safety, especially in the often hazardous environment in which the radiography is taking place. It was reassuring that all NDT companies stated that they provided their radiographers with at least one form of dosimeter. However, only 90% of radiographers stated that they knew what occupational doses they received. The implication is that the other 10% did not use dosimeters, either because dosimeters were not provided or the radiographers chose not to use them, or perhaps that they were uninterested in their doses.

The role of investigation levels could be more widely utilized. Less than two-thirds of NDT companies reported that they had established their own investigation levels, although a higher percentage said that the regulatory body had set such a level. All NDT companies should be using investigation levels. Of those that did have investigation levels, almost half reported that they had not performed any investigations in the last 5 years. This could be indicative of good practice, or it could suggest that investigation levels are set too high.

2.4.3.2. Safety of the public

Radiation protection for the public is afforded through ensuring that dose rates in areas accessible to the public are at levels which cannot lead to the public dose limits being exceeded, and by ensuring that members of the public do not enter a site where radiography is taking place.

Clearly, warning systems form an important part of protecting the public. Almost all regulatory bodies required the use of a warning system to prevent entry to the radiography site. Most of the regulatory bodies (80%) stated that they have a standard procedure for such a warning system, based mainly on barriers, and warning signs and lights. The average maximum dose rate allowed at the barrier, as set by the regulatory bodies, was 30 μSv/hr with a median of 10 μSv/hr. These values can be compared with the NDT company reported values of 13 μSv/h and 7.5 μSv/h for the mean and median, respectively, both of which are less than the regulatory body values.

One group of the public that are at particular risk with site radiography are other workers at the site. It is self-evident that these workers need to be aware that radiography is taking place, and that they need to understand the meaning of signage and warning lights. Conversely, the industrial radiographers need to know about particular aspects of the site that they are working at, including interfering activities. The results of the survey suggest that communication between the NDT company and the client is less than desirable. For example, the regulatory impetus is lacking — less than half of the regulatory bodies require the client (who is receiving the on-site radiography services) to inform the NDT company about conditions on the site that might affect the safety of other workers on site. This is then reflected in practice where the majority (70%), but not all, of NDT companies reported that their clients always provide information about other interfering activities on site.

A sizable proportion (60%) of NDT companies said that they had analysed reasons why unauthorized persons trespassed past the warning system. Wilful violation was the main cause, followed by ignorance about the meaning or purpose of the warning system. Both of these could be addressed through better communication between the NDT company and the client.

2.4.3.3. Safety of sources and exposure devices

Regulatory performance requirements set the basis for safety of sources and exposure devices. Most regulatory bodies (80%) stated that they required sources and exposure devices used for industrial radiography to meet specified standards, and 75% required X ray generators used for industrial radiography to meet specified standards.

Further, 80% of regulatory bodies required that the source and the exposure device be subject to periodic inspections/tests and maintenance to verify compliance with the required standards. For X ray generators, periodic inspections/tests and maintenance were required by 70% of regulatory bodies. This can be compared with the NDT company responses, where only 2 companies (2%) stated that preventative maintenance was not performed for exposure devices for gamma radiography, and only 1 company (1%) stated that preventative maintenance was not performed for X ray equipment.

The average interval specified by the regulatory bodies was 12 months for both gamma radiography devices and X ray equipment. The NDT company data gave an average interval of 8 months, again for both gamma and X ray devices, suggesting that the practice in industry is better than current regulatory requirements.

2.4.3.4. Compliance inspections

Checking that actual practice is indeed as it is supposed to be is an important part of radiation protection. High percentages of both the NDT companies and the regulatory bodies were performing compliance inspections of the radiographers at work. Both announced and unannounced inspections were being used. The results suggest that a radiographer could expect to be inspected at least twice a year by their NDT company and about once or twice a year by the regulatory body.

Both the NDT companies and regulatory bodies were asked in their respective questionnaires to rank the 5 most common shortcomings in their inspections. Table 3 compares these shortcomings. Two shortcomings were common — poor use of survey meters and dose rates at the boundary of the work site not being within limits. Two further related shortcomings of the regulatory body inspections (no proper warning systems to prevent entry to the work site and no proper use of alarm systems) were rated 6th and 7th respectively in the NDT company shortcomings. However, two of the shortcomings for NDT company inspections (poor use of collimators and no pre-operation specific equipment checks being performed) rated near the bottom of the regulatory body inspections' shortcomings.

It is possible that the results of the shortcomings reflect the different focus of the two forms of inspection — the NDT company inspections perhaps focussing more on whether the radiographer is following company procedures and protocols, while the regulatory body inspections may have a focus on public protection. Nonetheless, all the shortcomings have implications for radiation safety, and that shortcomings are found reinforces the continuing need for regular inspections.

TABLE 3. THE FIVE MOST COMMON SHORTCOMINGS FOR EACH OF NDT COMPANY AND REGULATORY BODY INSPECTIONS

Five most common shortcomings	
NDT company inspections	**Regulatory body inspections**
No proper use of collimators	No proper use of survey meters
Dose rate at the boundary of the work site not within limits set	No proper warning system to prevent entry to the work site
No proper use of survey meters	Poor emergency preparedness
No pre-operation specific equipment checks being performed	No proper use of alarm systems
Poor operator knowledge of procedures	Dose rate at the boundary of the work site not within limits set

2.4.3.5. Emergency preparedness and response

Radiation sources used for industrial radiography purposes have high radiation outputs and are potentially very hazardous. Incidents do occur and it is essential that systems are in place for emergency preparedness and response, in particular an emergency plan.

Almost all regulatory bodies (98%) stated that they require NDT companies to have an emergency plan; 95% of NDT companies stated that they had an emergency plan; and over 90% of radiographers stated that their NDT company had an emergency plan for site radiography.

The role of the radiographer in an emergency is crucial. Again, there seemed to be consistency across the questionnaires with almost 90% of radiographers reporting that they had received training for the roles and responsibilities of radiographers in the emergency plan; over 90% of NDT companies stated that their emergency plan was discussed with their radiographers and over 80% reported provided specific training on emergency preparedness and response. The last figure reflects the practice that some countries have requirements to use specialist persons in emergency roles, and hence specific training for radiographers in this role is not seen as appropriate.

Only three-quarters of regulatory bodies required NDT companies to have emergency equipment. However, 90% of NDT companies stated that they had emergency equipment for site radiography — primarily long tongs, shielding material, and an emergency or rescue container.

2.4.4. Individual monitoring

Figure 1 shows a comparison of the occupational dose distributions for industrial radiographers in 2009 assessed from the different questionnaires. The radiographer data are for 234 radiographers, the NDT company data are for nearly 3500 radiographers, and the regulatory body data are for over 16000 radiographers. Reassuringly, there is broad agreement

with the average annual effective dose from the radiographers' data and the regulatory bodies' data being 3.4 and 2.9 mSv, respectively. Some differences are, however, evident. For example, both the regulatory body data and the NDT company data show a higher proportion of radiographers receiving an annual dose less than 1 mSv – 60% and 58% respectively, while the radiographer data gave a lower proportion of 37%. Conversely, the radiographer-based data would suggest about twice as many radiographers receiving an annual dose in the range of 5–20 mSv compared with the NDT company and regulatory body data, namely 22% versus 9% and 12% respectively. The role of individual monitoring in industrial radiography is undisputed, with the need for good record keeping and regular review.

Figure 2 shows the distribution of annual effective dose for industrial radiographers versus their reported annual workloads. Clearly, there is no correlation. This emphasizes that occupational radiation protection in industrial radiography is not being effectively optimized.

Many factors can potentially affect occupational exposure in industrial radiography and there needs to be a systematic approach to the implementation of optimization of protection. The results of the survey are being used in this respect in two ways, as described in Sections 4.5 and 4.6.

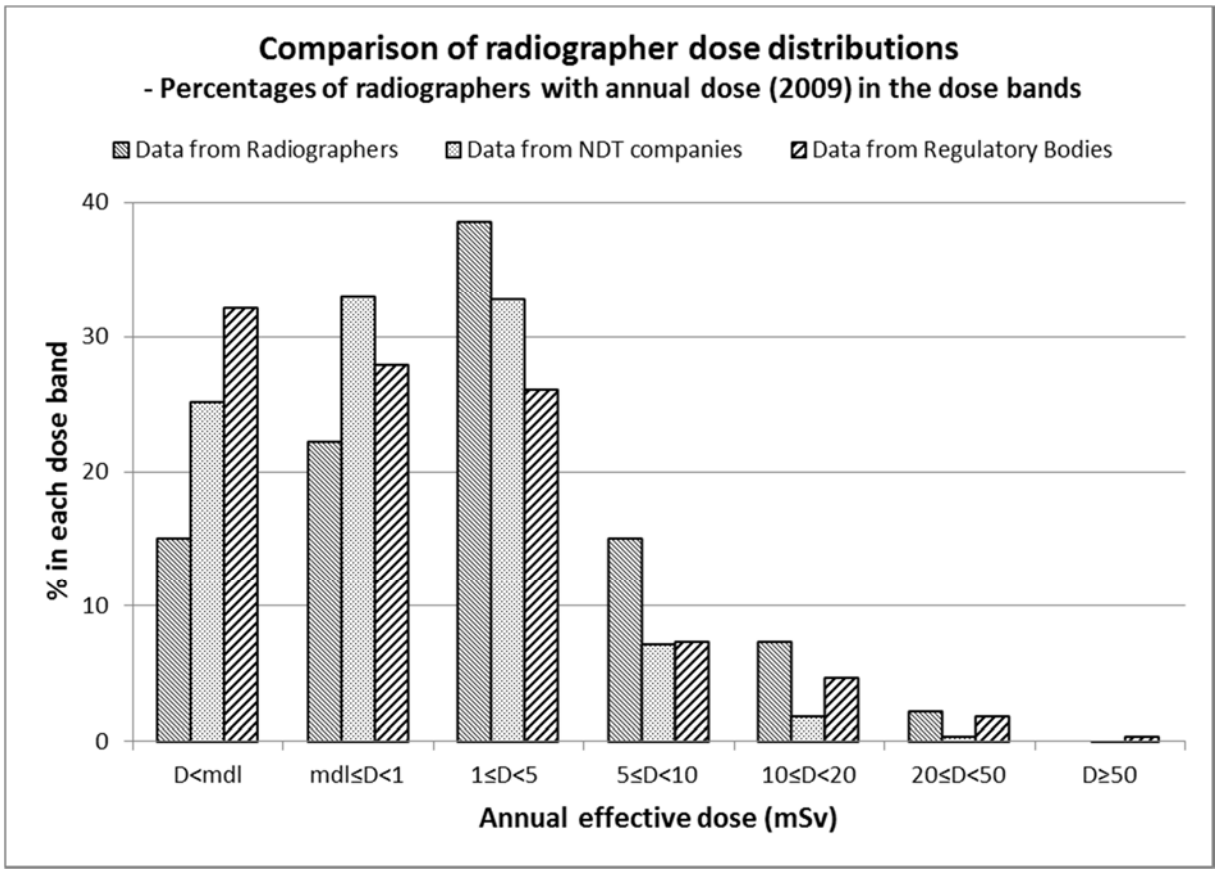

FIG. 1. Comparison of the annual dose distributions for industrial radiographers derived from the data from the radiographer questionnaire, the NDT company questionnaire and the regulatory body questionnaire. Note: 'mdl' means the minimum detection limit of the dosimetry system.

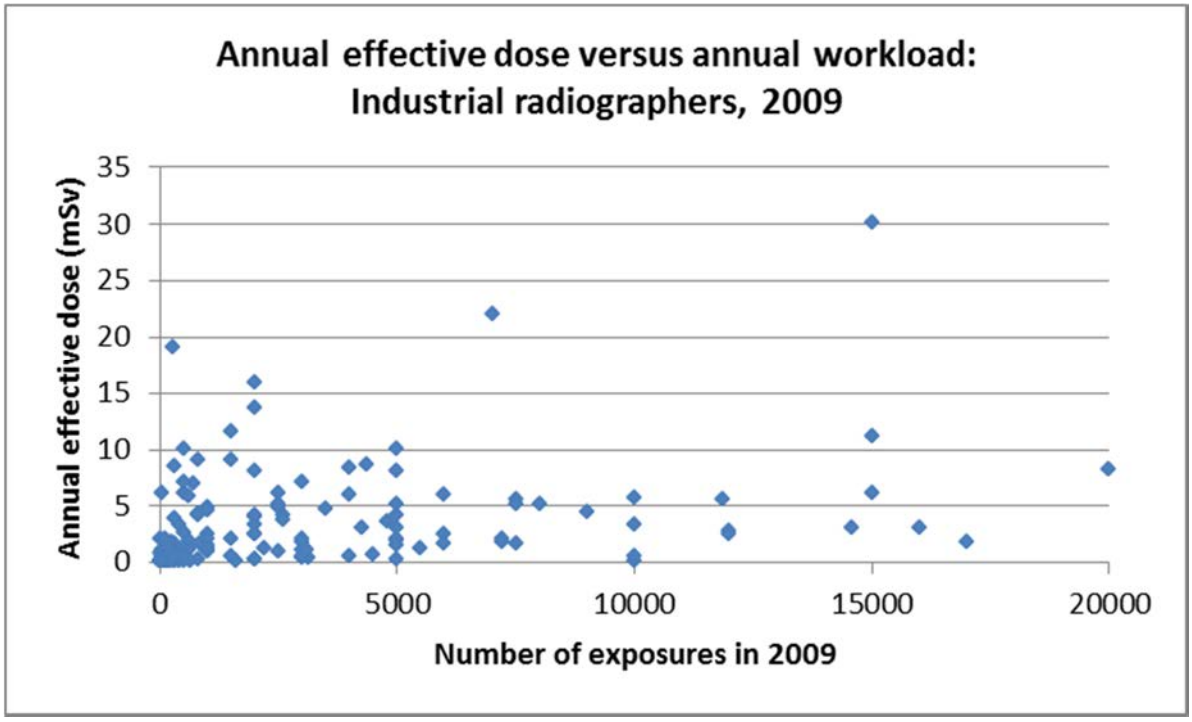

FIG. 2. The annual effective dose in 2009 for industrial radiographers versus the number of radiographic exposures for that radiographer. There was no correlation between dose and workload.

2.5. RECOMMENDATIONS ARISING FROM THE SURVEY

Based on the results of the survey, the WGIR considered the following recommendations to be appropriate:

- NDT companies should provide or facilitate initial training on radiation protection in industrial radiography, of at least one week duration and include at least two days of practical. Such radiation protection training is in addition to any that may have been received in the course of the NDT training.

- NDT companies should provide or facilitate refresher training on radiation protection in industrial radiography at least once every year, of at least one day duration and should include a practical exercise for creating a safe situation after a typical accident.

- Every NDT company should have an approved RPP, supported and regularly reviewed by top management.

- Every NDT company must either employ or contract an RPO, full or part-time as appropriate, who reports to the managing director.

- NDT companies should encourage the reporting of near-misses to allow analysis and lessons to be learned.

- NDT companies should ensure that feedback is given to radiographers on incidents that have been reported, for example at safety meetings.

- NDT companies should share information and experiences on incidents with other companies, e.g. through NDT societies or radiation protection societies.

- NDT companies should ensure that all radiographers use collimators or diaphragms for the sources and X ray units as the default. Any deviation from such practice must have been justified.

- NDT companies should provide all its radiographers with active dosimeters (in addition to the passive dosimeters), equipped with audible alarms and, where applicable, also with visual and/or vibrating alarms.

- NDT companies should ensure that all their radiographers are informed about their occupational doses every monitoring period.

- NDT companies should establish investigation levels, applied for each monitoring period.

- NDT company protocols for establishing the boundary of a controlled area should be based on a balance between the dose rate outside the controlled area, and the ability to maintain oversight of the area and to prevent entry.

- NDT companies should review the reasons why persons are not obeying the warning systems for preventing entry to the work area.

- NDT companies should ensure that their clients, where applicable, inform other workers at the site about the radiation risks associated with the performance of industrial radiography, the purpose and method of the warning systems and, in particular, the meaning of alarm signals.

- NDT companies should ensure that preventive maintenance of industrial radiography equipment is carried out according to the manufacturer's guidelines, and the frequency should be at least once per year, and more frequently when devices are used in harsh conditions.

- NDT companies should perform compliance inspections, with a mix of announced and unannounced inspections. Every radiographer should be inspected at least two times per year. The inspection team should consist of at least the RPO, who provides the radiation protection expertise, and a member of the management team, who would be promoting the importance of safety culture as well as reviewing corrective actions from previous inspections.

- All NDT companies must have an emergency plan and this needs to include the role required in that plan for the radiographers and, if applicable, for the clients. All NDT companies should include detailed knowledge of emergency procedures and steps required for creating a safe situation in the training given to their radiographers.

- All NDT companies should have an emergency exercise once a year, and review (with the participation of all) the results of that exercise.

- Regulatory bodies need to ensure that as a result of their authorization processes only NDT companies that meet accepted radiation protection standards (both for normal operations and emergency situations), such as in the IAEA's publication on radiation safety in industrial radiography [2], are permitted to practise industrial radiography.

- Regulatory bodies should consider the benefits of having a recognized qualification in radiation protection for industrial radiographers, and should set minimum standards for RPOs.

- Regulatory bodies should consider developing specific guidelines for safe practice of industrial radiography in their jurisdiction.

- Regulatory bodies should maintain specialized expertise in the area of industrial radiography to ensure effective regulatory activities in this area.

- Regulatory bodies should consider organizing an emergency task group to handle difficult situations that might arise.

- Regulatory bodies need to ensure that they provide clear guidance with respect to setting appropriate dose rates for the optimization of protection at the boundary of the radiography work area.

- Regulatory bodies should promote a safety culture among NDT companies, encouraging the reporting of incidents within companies and the sharing of lessons learned across companies.

- Client companies, when industrial radiography is being performed on their site, must assume overall responsibility for the coordination of all activities taking place on the site.

- Client companies, who regularly have industrial radiography performed on their site, should perform regular surveys of radiation protection practice at their sites.

- Client companies, who regularly have industrial radiography performed on their site, should consider having a radiation protection advisor or other similar expert to provide specific advice on radiation protection matters.

- Client companies must ensure that they have an emergency plan and that this is discussed with the on-site industrial radiographers.

- Industrial radiographers need to ensure that they receive regular refresher training in radiation protection.

- Industrial radiographers must know and follow their NDT company radiation protection and emergency procedures, and participate in radiation protection training programmes.

- Industrial radiographers must know and have regular contact with their RPO.

- Industrial radiographers must always wear active (with alarms) and passive individual dosimeters, appropriately positioned on the body.

- Industrial radiographers must always use hand-held survey meters.
- Industrial radiographers need to ensure they know their occupational doses.
- Industrial radiographers must report all incidents.
- Industrial radiographers need to ensure that they know their role in emergency situations.

2.6. CONCLUSIONS FROM THE SURVEY

A world-wide survey of occupational radiation protection in industrial radiography was performed over a period of about one year, from mid-2010 to mid-2011. Responses were received from 432 industrial radiographers, 95 NDT companies, and 59 regulatory bodies.

The results from the survey need to be interpreted with caution as the methods for distribution of the questionnaires to radiographers and NDT companies probably means that those that responded represent the better end of the practice spectrum.

Nonetheless, it could be concluded that:

- Initial radiation protection training for radiographers appears to be reasonably well established, but there is room for improvement especially with respect to refresher training. The corresponding regulatory basis needs to be more widely implemented.
- The occurrence or frequency of incidents (accidents, near missed and deviations) is not trivial, and methods such as better incident reporting, analysis, feedback and sharing lessons learned need to be better utilized.
- Collimators and diaphragms are not being used as often as they should be.
- Survey meters are not as widely available or used as they should be.
- Individual monitoring, as reported, is well established, with passive and, usually, active dosimeters. The regulatory basis for active dosimeters could be improved. The establishment and use of investigation levels needs to be improved.
- Warning systems to prevent entry to the work area during site radiography were not always as effective as desired. Better communication between all parties at the site is required.
- Preventive maintenance for the gamma sources, exposure devices and X ray equipment seem to be well established.
- An industrial radiographer has, on average, the expectation of being inspected by his/her NDT company at least twice a year, and by the regulatory body about once a year.
- Emergency plans were widely prevalent, but there seemed to be some issues regarding specific training for radiographers with respect to emergencies.

- Occupational doses received by radiographers varied considerably, with no correlation with radiographic workload.

In summary, the survey results indicate that there is a need for improved implementation of the radiation protection principle of optimization of protection and safety in industrial radiography world-wide.

3. A ROAD MAP

3.1. INTRODUCTION

As described in Section 2, the results of the worldwide survey on occupational radiation protection in industrial radiography showed that significant occupational doses do occur, accidents do happen, and the variation in occupational dose per radiographic exposure is considerable. In short, there is a need for considerable improvement in occupational radiation protection, especially in the implementation of optimization of protection.

To this end, the results of the survey were being used by the WGIR to develop two tools that aim to help practitioners in the field of industrial radiography. The first of these is the so-called 'road map' which will be described in this section.

3.2. APPROACH TO THE ROAD MAP

The experiences of designing and distributing the questionnaire addressed to the NDT companies, and then analyzing the responses naturally led to the idea of a 'road map' — a software tool that will enable NDT companies to assess their own performance in radiation protection against accepted practice.

Reflecting its heritage in the NDT company questionnaire, the road map is divided into 8 sections, namely:

1. Qualifications and training of industrial radiographers in radiation protection;
2. Learning from incidents (deviations from normal, near misses and accidents);
3. Individual monitoring;
4. Work place monitoring and warning systems;
5. Client interfaces;
6. Equipment;
7. Internal control and inspections;
8. Emergency preparedness and response.

In each of these sections there are a series of questions addressing particular aspects of each of these topics.

A representative from an NDT company would answer the questions in the road map, based on current practice in that company. The response to each question is then scored by comparing it with a measure of good practice. The measure for good practice, for each question, is based either on the relevant third quartile value from the distribution of responses from the survey or on a value given in an international standard. Different weightings are

applied to questions, depending on their relative importance, as established by the WGIR through consensus.

As an example, Table 4 lists five questions, in the section of the road map on 'Individual monitoring', on the dosimeters that are being provided to the industrial radiographers that work for the NDT company, and includes illustrative responses from a hypothetical NDT company. As can be seen from Table 4, the good practice answer to all questions, based on the survey results, is 'yes'. Further, different weightings are applied to different questions – for example, the provision of an active dosimeter is rated as very important and hence a relative weighting of 3, while the presence of a vibrating alarm is rated less important and assigned a relative weighting of 1.

TABLE 4. AN EXAMPLE OF QUESTIONS FROM THE ROAD MAP ON THE TOPIC OF INDIVIDUAL MONITORING, WITH ILLUSTRATIVE RESPONSES FROM A HYPOTHETICAL NDT COMPANY

Question from the Road Map	**NDT company response**	**Score**	**Good practice answer**	**Relative weighting**
Does your Company provide each of its radiographers with a passive individual dosimeter?	Yes	2.0	Yes	2
Does your Company provide each of its radiographers with an active individual dosimeter?	Yes	3.0	Yes	3
Are the active individual dosimeters equipped with visual alarms?	Yes	1.0	Yes	1
Are the active individual dosimeters equipped with audible alarms?	Yes	1.0	Yes	1
Are the active individual dosimeters equipped with vibrating alarms?	No	0.0	Yes	1

The scores for each section are summed and the results are presented to the user from the NDT company, including a graphical schematic that gives a quick visual overview of how the NDT company compares with current good practice. Areas that have been identified as being below par could then be addressed by the NDT company to improve occupational radiation protection in their facility. This is illustrated in Figure 3 for a hypothetical NDT company, which has good standards for the qualifications and training of its radiographers, but has some deficiencies in most other areas of occupational radiation protection practice.

The road map tool is available on the ISEMIR pages of the IAEA's ORPNET website at:

http://www-ns.iaea.org/tech-areas/communication-networks/norp/isemir-wgir.htm

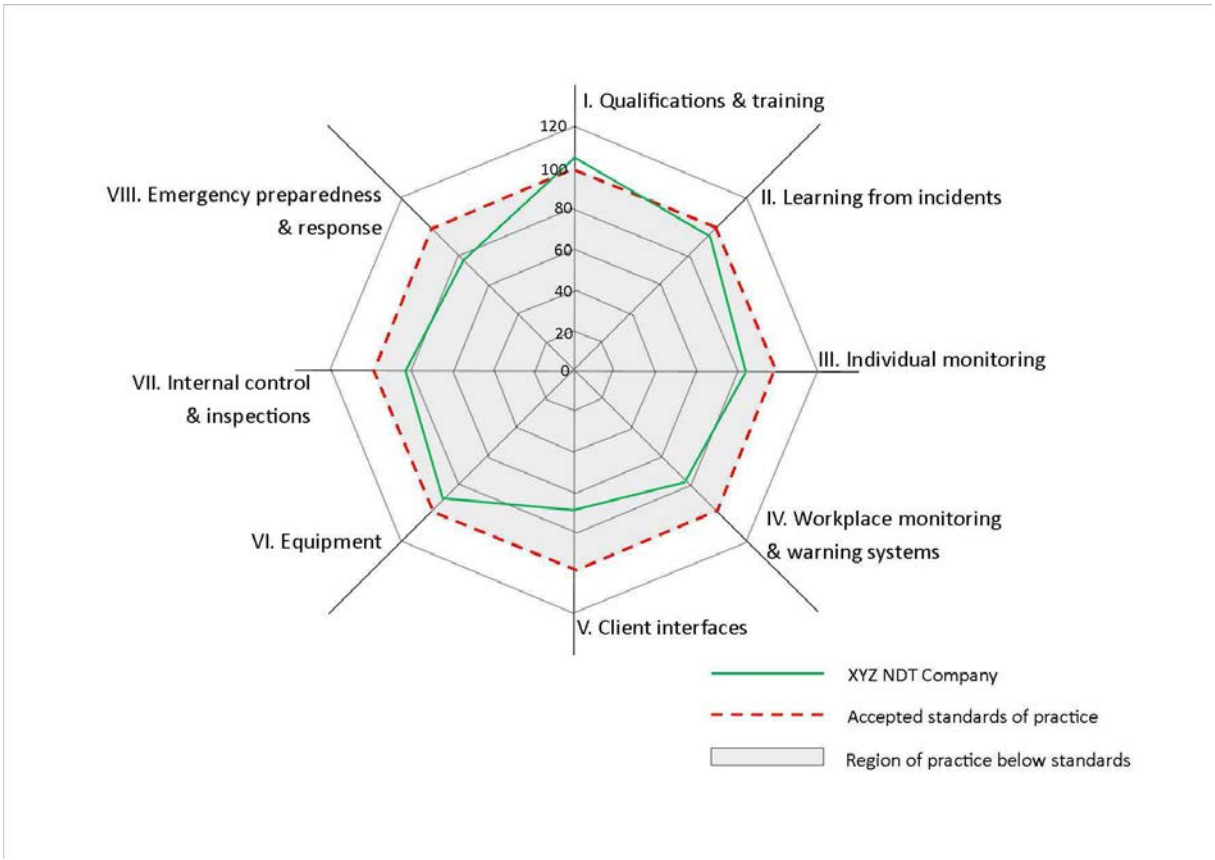

FIG. 3. Overview of the assessment of a hypothetical NDT company as determined by the road map, highlighting that the company has industrial radiographers with good qualifications and training, but with some deficiencies in all other areas of occupational radiation protection.

4. ISEMIR INTERNATIONAL DATABASE — ISEMIR-IR

4.1. INTRODUCTION

A carefully designed database can be an effective tool for the implementation of optimization of occupational radiation protection. One of the original longer term aims of the ISEMIR project was to utilize such an approach. In the context of IR, there was a need to explore the feasibility of setting up a system for the regular collection and analysis of occupational doses for individuals in IR, and for the use of this information to improve occupational radiation protection.

As described in Section 2, the worldwide survey showed that occupational radiation protection data could be obtained directly from IR facilities. The data collected were able to demonstrate the clear need worldwide for improved optimization of occupational radiation protection in IR. The data collected also provided confirmation that, with sufficient data, analyses could be performed comparing doses for specific occupational roles and conditions, assessing the impact of radiation protection actions, and for following dose trends.

These experiences underlined the need for an international database for specific occupational groups, with appropriate analysis functionality. This has led to the design and development of the ISEMIR international database. The purpose of the ISEMIR database is not to assess compliance with occupational dose limits, but rather to be an active tool for assessing the level of, and hence guiding, implementation of the radiation protection principle of optimization of protection at a given IR facility.

4.2. DATABASE STRUCTURE

The ISEMIR international database is being developed to provide a web-based tool to help end-users improve their implementation of optimization in occupational radiation protection in particular targeted areas. The ISEMIR database will have a database dedicated to IR, called ISEMIR-IR and described in more detail below.

The database is structured around individual IR facilities (NDT companies). In designing the database it was important to avoid collecting unnecessary data but, at the same time, to ensure that there would be sufficient resolution to allow useful analysis and hence provide the information to then help improve the implementation of optimization in occupational radiation protection. In other words, the database has to contain as much information about the factors that could influence the occupational dose of an individual person in IR as possible, without tipping the balance to make participation in the database an unattractive time consuming burden. As a result, some fields in the database will be mandatory and others will be optional.

Each participating NDT company will provide a company profile, including the sources used and company procedures and training relating to radiation protection.

Each participating NDT company will also provide information on individual industrial radiographers in the company, including their occupational doses, their role, radiographic workloads, level of NDT training, radiation protection training, sources used, percentage of

site radiography, use of collimators, use of survey meters, and the number of accidents, near misses and deviations. Data will be entered per calendar year, with an additional option of monthly data for occupational doses and radiographic workloads. Individuals and facilities will be anonymised in the database.

There must be a means for assessing the effectiveness of the optimization of protection in an NDT company. The metric will be the occupational dose per radiographic exposure for a given industrial radiographer. Statistics on the distribution of dose metrics can then be determined for any combination of the aforementioned personnel attributes — role, level of NDT training, radiation protection training, sources used, percentage of site radiography, use of collimators, use of survey meters, and the number of accidents, near misses and deviations. This is illustrated in Figure 4.

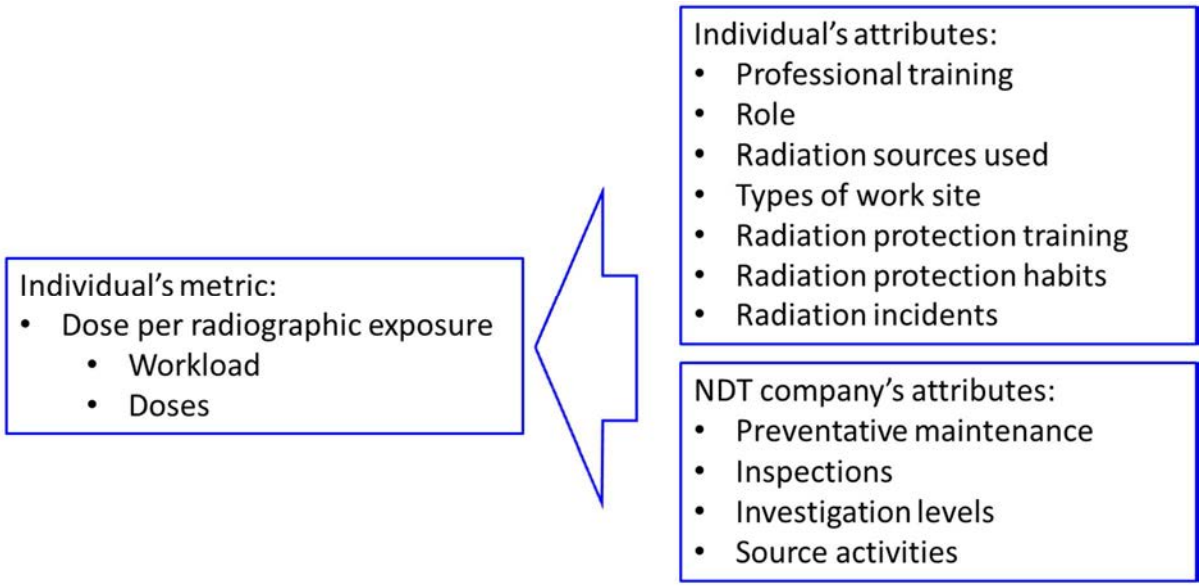

FIG. 4. The performance of any individual can be assessed by deriving statistics on the distribution of the dose metric as a function of one or more of the individual attributes and the facility's attributes.

The ISEMIR-IR database would also have a module devoted to incidents — accidents, near misses and deviations from normal. This module is intended to be a tool to provide information that should lead to a reduction in the occurrence of incidents in industrial radiography. Its features would include examples of incidents for training; the ability to search for incidents related to a given factor, such as cause, equipment, conditions; provision of details on actual corrective actions implemented; and promotion of lessons learned.

4.3. ANALYSIS AND REPORTING

Once populated, the database will support three broad types of analyses — occupational doses per procedure as a function of personnel and facility attributes; benchmarking; and trends with time.

4.3.1. Statistical analysis

Statistical analysis on the dose metrics for a given group of persons can be used to identify areas that could be improved or, on the other hand, that represent good practice.

A registered IC facility user will be able to perform statistical analyses of occupational effective dose per procedure, eye dose per procedure and hand dose per procedure, based on combinations (one or more) of the individuals' personal attributes and facility attributes. In particular, this will include estimates of expected 'population' means for these combinations of attributes.

This can be illustrated using data from the worldwide survey (Section 2). The industrial radiographers were divided into two groups based on their use of collimators when performing radiography with gamma sources — the first group reported that they always used collimators, while the second group reported that they sometimes used collimators. The estimates of mean effective dose per exposure were 3.3 ± 1.6 and 4.2 ± 2.1 µSv per procedure for the group that always used collimators and the group that sometimes used collimators, respectively, as given in Figure 5. While the difference in this case was not statistically significant, it illustrates the analysis that could be made with the potential power of a larger international database with more data. Such analysis would help NDT companies identify means for improving radiation protection of their industrial radiographers.

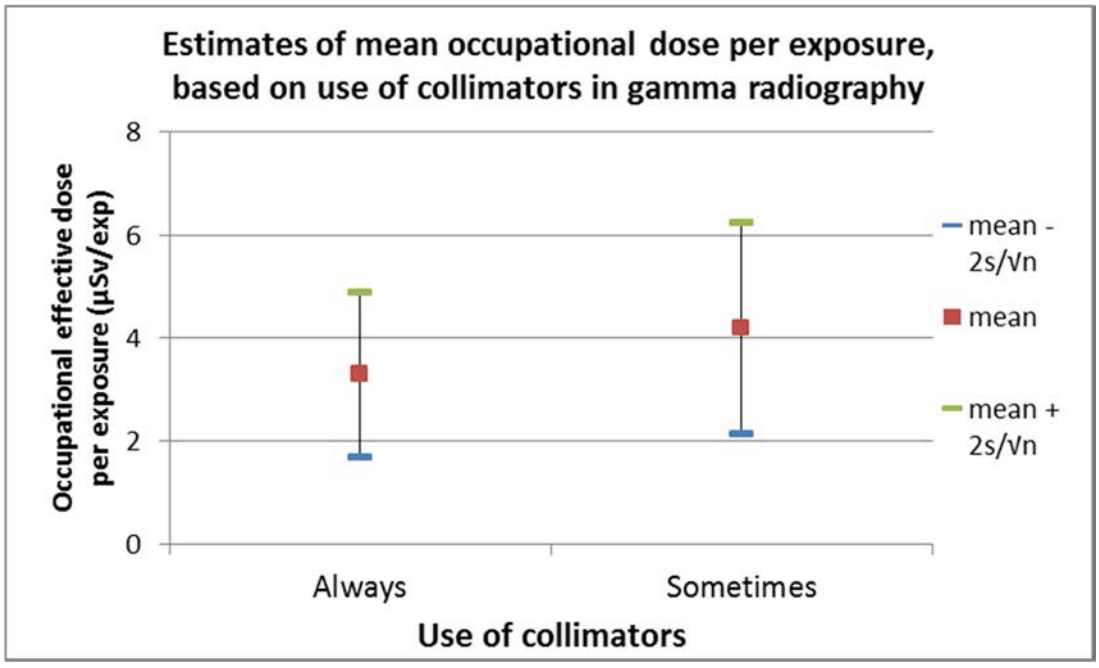

FIG. 5. Estimates of mean occupational effective dose per radiographic exposure when performing industrial radiography with gamma sources, as a function of whether collimators are always used or only sometimes used. The mean for the former was 3.3 µSv, and the latter 4.2 µSv.

4.3.2. Benchmarking

NDT companies will be able to benchmark their own company and individual personnel performances against global or regional data and identify areas for improvement and

corrective actions that should lead to an improvement in radiation protection. This can occur by benchmarking an NDT company or an individual from the NDT company.

For example, the NDT company's performance could be benchmarked against all other NDT companies — i.e. the data are analysed on a 'per NDT company' basis, giving distributions of NDT company-based statistics, such as NDT company mean effective dose per radiographic exposure for qualified industrial radiographers, thus giving the basis for benchmarking. Alternatively, the occupational effective dose per procedure for an individual from the NDT company could be compared with the distribution of individuals in the database, selected on the basis of combinations of individuals' attributes that match the individual being benchmarked, again with the option of regional specificity. Other analyses will also be possible.

4.3.3. Trends in time

Analyses of occupational doses per radiographic exposure over successive years will be able to be displayed as a function of time. These analyses will be able to be modified as needed by the NDT company user.

4.4. ISEMIR-IR — THE LAUNCH

The ISEMIR-IR database is to be developed in stages, as resources permit:

- Stage 1. Data entry on doses, workload, radiation protection training and radiation protection practice for IR personnel in an NDT company;
- Stage 2. Statistical analysis, benchmarking and reporting tools, and improved data entry;
- Stage 3. Development of the module for incident reporting and analysis.

Detailed design for Stages 1 and 2 has been completed, and it is anticipated that Stage 1 will be developed in 2014, followed by Stages 2 and 3.

Once developed, NDT companies all around the world would be encouraged to actively participate in the database to enable it to become a viable tool for implementing optimization of occupational radiation protection in industrial radiography.

5. CONCLUSIONS

The activities of the WGIR of the ISEMIR project allow the following conclusions:

A world-wide survey of occupational radiation protection in industrial radiography, performed over a period of about one year from mid-2010 to mid-2011, provided insight into the then current status of occupational radiation protection in NDT companies around the world. The survey results indicated that there is a need for improved implementation of the radiation protection principle of optimization of protection and safety in industrial radiography world-wide.

The results of the world-wide survey of occupational radiation protection in industrial radiography have led to the development of two tools to assist with improved implementation of the radiation protection principle of optimization of protection.

A road map software tool has been developed that will allow an NDT company to perform a self-assessment of its own performance with respect to radiation protection against current good practice.

The ISEMIR-IR database is being developed to provide a tool that can be used by NDT companies to improve their implementation of optimization of occupational radiation protection in industrial radiography. Once developed, NDT companies all around the world will need to be encouraged to actively participate in the database to enable it to become a viable tool for implementing optimization of occupational radiation protection.

APPENDIX I. DETAILED RESULTS OF THE QUESTIONNAIRE ON OCCUPATIONAL RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY ADDRESSED TO OPERATORS

I.1. INTRODUCTION

The principal findings from the operator questionnaire are given in Section 2.3, together with results from the other questionnaires. Appendix I gives additional data in the form of tables and figures. Many of the table headings refer to a specific question number in the operator questionnaire. For reference, the questions from the questionnaire are given in Appendix IV.

The term 'operator' in the context of the questionnaire means an individual industrial radiographer. The abbreviation RP is often used for 'radiation protection' in the following tables and figures. In many of the tables and figures, 'Min' means minimum, 'Q1' means first quartile, 'Q3' means third quartile, 'Max' means maximum, and 'SD' means standard deviation. Note, not all questions were answered by all responders.

I.2. RESPONSES TO THE OPERATOR QUESTIONNAIRE

This Section presents the details from the responses to the operator questionnaire. The questions from the questionnaire are given in Appendix IV. Further analysis of the responses is given in Section I.3.

I.2.1. Number of responses to the operator questionnaire

TABLE 5. DETAILS OF RESPONSES TO THE OPERATOR QUESTIONNAIRE

	Number of operators	Number of NDT companies	Number of countries
Africa	17	7	3
Asia-Pacific	49	36	7
Europe	166	60	16
Latin America	72	17	3
North America	128	33	2
Global	**432**	**153**	**31**

TABLE 6. ESTIMATED NUMBER OF RESPONSES TO THE OPERATOR QUESTIONNAIRE PER NDT COMPANY

Number of operators responding per NDT company	Number of NDT companies
1	101
2 - 5	29
6 - 10	17
10 - 20	4
> 20	2

I.2.2. Radiation protection training

I.2.2.1. Radiation protection training — part of NDT training on radiographic testing

Question 1 of the questionnaire asked the industrial radiographer whether radiation protection training was included in his/her NDT training on radiographic testing. Each radiographer was asked to answer for all levels of NDT training applicable to them.

TABLE 7. RESPONSES TO QUESTION 1 — WAS RADIATION PROTECTION TRAINING INCLUDED IN YOUR LEVEL 1 NDT TRAINING ON RADIOGRAPHIC TESTING?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	11	2	0	4	17
Asia-Pacific	37	0	0	12	49
Europe	85	19	6	56	166
Latin America	61	3	2	6	72
North America	92	0	3	33	128
Global	**286**	**24**	**11**	**111**	**432**

TABLE 8. RESPONSES TO QUESTION 1 — WAS RADIATION PROTECTION TRAINING INCLUDED IN YOUR LEVEL 2 NDT TRAINING ON RADIOGRAPHIC TESTING?'

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	8	0	1	8	17
Asia-Pacific	33	0	2	14	49
Europe	109	23	5	29	166
Latin America	18	4	1	49	72
North America	81	1	3	43	128
Global	**249**	**28**	**12**	**143**	**432**

TABLE 9. RESPONSES TO QUESTION 1 — WAS RADIATION PROTECTION TRAINING INCLUDED IN YOUR LEVEL 3 NDT TRAINING ON RADIOGRAPHIC TESTING?

	Yes	No	Don't know	No reply	Total
Africa	5	0	1	11	17
Asia-Pacific	12	2	6	29	49
Europe	20	12	9	125	166
Latin America	4	2	1	65	72
North America	6	3	4	114	128
Global	**47**	**19**	**21**	**344**	**432**

TABLE 10. HIGHEST LEVEL OF NDT TRAINING OF RESPONDING OPERATORS, DERIVED FROM THEIR RESPONSES TO QUESTION 1

	Highest NDT level attained — number and percentage* of operators			Sub-total of responses indicating an NDT level	No reply	Total
	Level 1	Level 2	Level 3			
Africa	6 (35)*	6 (35)	5 (30)	17	0	17
Asia-Pacific	14 (29)	21 (43)	14 (29)	49	0	49
Europe	18 (12)	105 (68)	32 (21)	155	11	166
Latin America	47 (68)	16 (23)	6 (9)	69	3	72
North America	36 (31)	73 (62)	9 (8)	118	10	128
Global	**121 (30)**	**221 (54)**	**66 (16)**	**408**	**24**	**432**

* Percentage (given in parentheses) of those responses that indicated an NDT level of training.

I.2.2.2. Radiation protection training — separate

Question 2 of the questionnaire asked the industrial radiographer whether he/she had received separate radiation protection training, either in addition to or instead of any radiation protection training in their NDT training on radiographic testing.

TABLE 11. RESPONSES TO QUESTION 2 — DID YOU RECEIVE SEPARATE TRAINING ON RADIATION PROTECTION, EITHER IN ADDITION TO OR INSTEAD OF ANY RADIATION PROTECTION TRAINING IN YOUR NDT-TRAINING?

	Yes	No	Don't know	No reply	Total
Africa	13	4	0	0	17
Asia-Pacific	41	8	0	0	49
Europe	137	28	1	0	166
Latin America	66	6	0	0	72
North America	107	15	1	5	128
Global	**364**	**61**	**2**	**5**	**432**

TABLE 12. RESPONSES TO 2a — IF YES TO QUESTION 2, DO YOU HAVE A FORMAL RADIATION PROTECTION QUALIFICATION OR CERTIFICATION?

	Yes	No	Don't know	No reply	Total
Africa	8	5	0	0	13
Asia-Pacific	38	2	0	1	41
Europe	121	10	3	3	137
Latin America	62	3	0	1	66
North America	83	18	5	1	107
Global	**312**	**38**	**8**	**6**	**364**

Comparing the responses to Questions 1 and 2 (see Tables 7–12), it appears that 8 responding operators had not had radiation protection training, either as part of NDT training or as separate training.

I.2.2.3. Radiation protection training — emergency procedures

Question 3 of the questionnaire asked the industrial radiographer whether he/she had received training in emergency procedures as part of their radiation protection training.

TABLE 13. RESPONSES TO QUESTION 3 — IF YOU HAVE HAD RADIATION PROTECTION TRAINING, WERE PROCEDURES FOR EMERGENCIES INCLUDED IN THE TRAINING?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	14	3	0	0	17
Asia-Pacific	46	3	0	0	49
Europe	126	27	7	6	166
Latin America	72	0	0	0	72
North America	117	5	2	4	128
Global	**375**	**38**	**9**	**10**	**432**

Of the 38 'no' responses in Table 13, 5 were operators who used X ray sources only, and 10 were operators who did not specify what sources they worked with. However, 27 operators who stated that they worked with X rays sources only also reported that they had been trained in emergency procedures.

TABLE 14. RESPONSES TO QUESTION 3a — IF YES TO QUESTION 3, DID THE TRAINING INCLUDE PRACTICAL EXERCISES FOR CREATING A SAFE SITUATION UNTIL THE SOURCE IS ABLE TO BE RECOVERED?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	12	1	0	1	14
Asia-Pacific	39	6	0	1	46
Europe	67	57	2	0	126
Latin America	56	12	0	4	72
North America	73	42	2	0	117
Global	**247**	**118**	**4**	**6**	**375**

Of the 118 'no' responses in Table 14, 8 operators were operators who used X ray sources only, and 12 were operators who did not specify what sources they worked with. However, 16 operators who stated that they worked with X rays sources only reported that they had had practical exercises for creating a safe situation.

TABLE 15. RESPONSES TO QUESTION 3b: — IF YES TO QUESTION 3, DID THE TRAINING INCLUDE PRACTICAL EXERCISES FOR SOURCE RECOVERY?

	Yes	No	Don't know	No reply	Total
Africa	11	1	0	2	14
Asia-Pacific	29	12	3	2	46
Europe	49	62	0	15	126
Latin America	57	9	2	4	72
North America	49	56	2	10	117
Global	**195**	**140**	**7**	**33**	**375**

Of the 140 'no' responses in Table 15, 11 were operators who used X ray sources only, and 18 were operators who did not specify what sources they worked with. However, 11 operators who stated that they worked with X rays sources only also reported that they had had practical exercises for source recovery.

TABLE 16. RESPONSES TO QUESTION 3C — ARE YOU ALLOWED TO PERFORM A SOURCE RECOVERY ON YOUR OWN WITHOUT FIRST CONTACTING A SPECIALIZED SOURCE RECOVERY PERSON?

	Yes	No	Don't know	No reply	Total
Africa	1	14	0	2	17
Asia-Pacific	12	23	1	13	49
Europe	20	124	15	7	166
Latin America	38	27	4	3	72
North America	8	114	1	5	128
Global	**79**	**302**	**21**	**30**	**432**

With regards to source recovery, many countries do not allow operators to perform recoveries, with this operation being restricted to specialist persons. Of the 79 operators that were allowed to perform source recovery, 71 had had separate radiation protection training and 62 had had practical training on source recovery.

14 (of the 79) operators had level 3 NDT radiographic technique training, 33 level 2, 29 had level 1, and 3 had not specified their radiographic technique training. These proportions are similar to the overall proportions of responding operators in each level of NDT training, suggesting that the level of radiographic technique training in itself has little correlation with being allowed to perform source recovery.

In the above tables on emergency training (Tables 13–16), approximately 90% of the 'yes' responders had indicated that they had had separate radiation protection training. There is always the possibility that specific emergency training, for example for creating a safe situation, may be given through licensee procedures rather than formal radiation protection training.

TABLE 17. FURTHER ANALYSIS OF RESPONSES ON TRAINING IN EMERGENCY PROCEDURES

	Number of operators with emergency training that included practicals for:				**Number of operators that had had emergency training**
	Creating a safe situation, but not source recovery	**Source recovery, but not creating a safe situation**	**Both creating safe situations & source recovery**	**Details not specified**	
Africa	1	0	11	2	14
Asia-Pacific	10	0	29	7	46
Europe	20	2	47	57	126
Latin America	4	5	52	11	72
North America	25	1	48	43	117
Global	**60**	**8**	**187**	**120**	**375**

Questions 4 and 4a of the questionnaire asked the industrial radiographer whether he/she felt sufficiently qualified and trained to be able to work safely and reliably, and whether he/she were well prepared for an emergency situation.

TABLE 18. RESPONSES TO QUESTION 4 — DO YOU FEEL SUFFICIENTLY WELL QUALIFIED AND TRAINED TO BE ABLE TO WORK SAFELY AND RELIABLY?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	16	1	0	0	17
Asia-Pacific	46	2	0	1	49
Europe	153	6	5	2	166
Latin America	71	1	0	0	72
North America	124	0	0	4	128
Global	**410**	**10**	**5**	**7**	**432**

TABLE 19. RESPONSES TO QUESTION 4a – DO YOU FEEL YOU ARE WELL PREPARED FOR AN EMERGENCY SITUATION?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	15	1	1	0	17
Asia-Pacific	43	4	0	2	49
Europe	124	28	9	5	166
Latin America	60	5	6	1	72
North America	113	2	6	7	128
Global	**355**	**40**	**22**	**15**	**432**

TABLE 20. FURTHER ANALYSIS OF THE 'NO' RESPONSES GIVEN IN TABLE 19

		Responded 'No' and:				
	'No' response	**Had no training in creating a safe situation**	**Had no source recovery training**	**Had no training in creating a safe situation or in source recovery**	**Was not allowed to perform source recovery**	**Had no training in creating a safe situation or in source recovery or were not allowed to perform source recovery**
Africa	1	0	0	0	0	0
Asia-Pacific	4	0	2	2	2	4
Europe	28	13	13	14	23	25
Latin America	5	5	2	5	4	5
North America	2	0	0	0	2	2
Global	**40**	**18**	**17**	**21**	**31**	**36**

There was no correlation between the level of NDT training and feeling 'not well prepared'.

I.2.3. On-site presence of a qualified radiation safety expert

Question 5 of the questionnaire asked the industrial radiographer whether a qualified radiation safety expert was on the work site and supervising the work, or whether a qualified radiation safety expert monitored or audited the safe operation of the work on a regular basis.

TABLE 21. RESPONSES TO QUESTION 5a – WHEN ON-SITE RADIOGRAPHY IS BEING PERFORMED, IS THERE A QUALIFIED RADIATION SAFETY EXPERT, WHO IS ON THE WORK SITE AND SUPERVISES THE JOBS?

	Always	Sometimes	Never	Don't know	No reply	Total
Africa	12	4	1	0	0	17
Asia-Pacific	33	11	1	0	4	49
Europe	61	75	16	9	5	166
Latin America	53	14	0	1	4	72
North America	73	37	8	6	4	128
Global	**232**	**141**	**26**	**16**	**17**	**432**

TABLE 22. RESPONSES TO QUESTION 5b – WHEN ON-SITE RADIOGRAPHY IS BEING PERFORMED, IS THERE A QUALIFIED RADIATION SAFETY EXPERT, WHO MONITORS OR AUDITS THE SAFE OPERATION OF THE JOBS ON A REGULAR BASIS?

	Always	Sometimes	Never	Don't know	No reply	Total
Africa	9	7	1	0	0	17
Asia-Pacific	21	14	1	0	13	49
Europe	72	80	5	4	5	166
Latin America	38	26	3	1	4	72
North America	35	77	6	6	4	128
Global	**175**	**204**	**16**	**11**	**26**	**432**

I.2.4. Safety check on source presence

Questions 6 and 7 of the questionnaire asked the industrial radiographer whether he/she checked for the presence of the source in the exposure device before taking the device from the store, and after the NDT test, respectively.

TABLE 23. RESPONSES TO QUESTION 6 — DO YOU CHECK FOR THE PRESENCE OF THE SOURCE IN THE EXPOSURE DEVICE BEFORE TAKING THE DEVICE FROM THE STORE?

	Always	Sometimes	Never	Don't know	No reply	Total
Africa	15	2	0	0	0	17
Asia-Pacific	47	1	0	0	1	49
Europe	130	16	14	0	6	166
Latin America	64	5	0	0	3	72
North America	117	5	2	0	4	128
Global	**373**	**29**	**16**	**0**	**14**	**432**

There was no obvious pattern to the 16 'never' responses in Table 23 — operators either using X rays only or working with non-specified sources accounted for only 1 and 2 of the 'never' responses, respectively.

TABLE 24. RESPONSES TO QUESTION 7 — DO YOU CHECK FOR THE PRESENCE OF THE SOURCE IN THE EXPOSURE DEVICE AFTER THE NDT TEST?

	Always	Sometimes	Never	Don't know	No reply	Total
Africa	17	0	0	0	0	17
Asia-Pacific	47	2	0	0	0	49
Europe	147	9	5	0	5	166
Latin America	66	2	0	0	4	72
North America	119	4	0	0	5	128
Global	**396**	**17**	**5**	**0**	**14**	**432**

Of the 5 'never' responses in Table 24, none was an operator using X rays only and only 1 was an operator using non-specified sources.

I.2.5. Radiation incidents

Question 8 of the questionnaire asked the industrial radiographer whether he/she had had any incidents (i.e. deviations from normal, near misses or accidents) with respect to radiation and hence occupational exposure during the last 5 years. If there had been such incidents, numbers were asked for.

TABLE 25. RESPONSES TO QUESTION 8 — HAVE YOU HAD ANY INCIDENTS (I.E. DEVIATIONS FROM NORMAL, NEAR MISSES OR ACCIDENTS) WITH RESPECT TO RADIATION AND HENCE OCCUPATIONAL EXPOSURE DURING THE LAST 5 YEARS?

	Yes	No	Don't know	No reply	Total
Africa	3	13	0	1	17
Asia-Pacific	8	38	1	2	49
Europe	33	128	4	1	166
Latin America	13	56	0	3	72
North America	26	99	0	3	128
Global	**83**	**334**	**5**	**10**	**432**

TABLE 26. RESPONSES TO QUESTION 8a — HOW MANY DEVIATIONS FROM NORMAL WERE THERE IN THE LAST 5 YEARS?

	Replies	No value given	Number of deviations from normal						
			Total	Mean	Min	Q1	Median	Q3	Max
Africa	15	2	0	0	0	0	0	0	0
Asia-Pacific	44	5	18	0.4	0	0	0	0	6
Europe	161	5	153	1.0	0	0	0	0	100
Latin America	69	3	11	0.2	0	0	0	0	3
North America	120	8	47	0.4	0	0	0	0	12
Global	**409**	**23**	**229**	**0.6**	**0**	**0**	**0**	**0**	**100**

One operator reported 100 deviations. This is included in the analysis in Table 26, but it is noted that the next highest value was only 12. Excluding this datum gives a global total of 129 deviations and a mean of 0.3.

TABLE 27. RESPONSES TO QUESTION 8a — HOW MANY NEAR MISSES WERE THERE IN THE LAST 5 YEARS?

	Replies	No value given	Number of near misses						
			Total	Mean	Min	Q1	Median	Q3	Max
Africa	15	2	2	0	0	0	0	0	1
Asia-Pacific	44	5	2	0.0	0	0	0	0	2
Europe	161	5	18	0.1	0	0	0	0	2
Latin America	69	3	9	0.1	0	0	0	0	3
North America	120	8	10	0.1	0	0	0	0	5
Global	**409**	**23**	**41**	**0.1**	**0**	**0**	**0**	**0**	**5**

TABLE 28. RESPONSES TO QUESTION 8a — HOW MANY ACCIDENTS WERE THERE IN THE LAST 5 YEARS?

	Replies	No value given	Number of accidents						
			Total	Mean	Min	Q1	Median	Q3	Max
Africa	15	2	0	0.000	0	0	0	0	0
Asia-Pacific	44	5	6	0.136	0	0	0	0	4
Europe	161	5	5	0.031	0	0	0	0	2
Latin America	69	3	3	0.043	0	0	0	0	1
North America	120	8	2	0.017	0	0	0	0	1
Global	**409**	**23**	**16**	**0.039**	**0**	**0**	**0**	**0**	**4**

The following comments are relevant for Tables 26–28:

- If the response to Question 8 (Table 25) was ‘yes’, but values were given for only some of the number of deviations, near misses and accidents for the last 5 years, then a value of 0 was assigned for the missing data. If however the response to Question 8 was ‘yes’ but no values were given, then no values were assigned.

- If the response to Question 8 (Table 25) was ‘no’, then a value of 0 was assigned for each of the number of deviations, near misses and accidents for the last 5 years.

- If the response to Question 8 (Table 25) was either ‘do not know’ or ‘blank’, then no values were assigned for each of the number of deviations, near misses and accidents for the last 5 years.

Question 9 of the questionnaire asked the industrial radiographer whether he/she had reported their deviations, near misses or accidents to their NDT company and, if so, whether the NDT company had reported these to the radiation protection regulatory body.

TABLE 29. RESPONSES TO QUESTION 9 — IF YOU HAD DEVIATIONS, NEAR MISSES, OR ACCIDENTS IN THE LAST 5 YEARS, DID YOU REPORT THESE TO YOUR COMPANY?

	Always	**Sometimes**	**Never**	**Don’t know**	**No reply**	**Total**
Africa	1	1	1	0	0	3
Asia-Pacific	8	0	0	0	0	8
Europe	28	2	2	0	1	33
Latin America	11	2	0	0	0	13
North America	23	0	3	0	0	26
Global	**71**	**5**	**6**	**0**	**1**	**83**

TABLE 30. RESPONSES TO QUESTION 9a — IF YES TO QUESTION 9, DID YOUR NDT COMPANY REPORT ANY OF THESE TO THE (RADIATION PROTECTION) REGULATORY BODY?

	Yes	**No**	**Don’t know**	**No reply**	**Total**
Africa	0	1	0	1	2
Asia-Pacific	7	0	1	0	8
Europe	11	5	14	0	30
Latin America	5	3	5	0	13
North America	10	6	6	1	23
Global	**33**	**15**	**26**	**2**	**76**

Table 30 reports what each operator believed occurred in the company they work for. Of the 76 individual operators that responded ‘always’ or ‘sometimes’ to Question 9 (Table 29), 21 were the sole responders for their company. The other 55 operators came from 25 different companies, making a total of 46 NDT companies reflected in this table. For most NDT

companies with multiple operators, the majority did not provide responses to these questions. However, for 3 NDT companies there were 4 instances of contradictory responses — i.e. one or more operators said that the events were reported to the RB and one or more said they were not.

TABLE 31. RESPONSES TO QUESTION 9b — IF YES TO QUESTION 9a, WHICH TYPE WERE REPORTED: ALL CASES; NEAR MISSES AND ACCIDENTS; OR ACCIDENTS ONLY?

	Total number responding 'yes' to reporting to the RB	**No. of operators who stated that their NDT company reported to the RB the following events:**		
		All cases	**Near misses & accidents**	**Accidents only**
Africa	0	0	0	0
Asia-Pacific	7	5	3	2
Europe	11	10	2	2
Latin America	5	1	2	0
North America	10	7	0	1
Global	**33**	**23**	**7**	**5**

I.2.6. NDT company emergency plan for site radiography

Question 10 of the questionnaire asked the industrial radiographer whether the NDT company he/she worked for had an emergency plan for site radiography and, if so, whether he/she had received training for the roles and responsibilities of radiographers in that plan.

TABLE 32. RESPONSES TO QUESTION 10 — DOES THE NDT COMPANY YOU WORK FOR HAVE AN EMERGENCY PLAN FOR SITE RADIOGRAPHY?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	15	1	1	0	17
Asia-Pacific	45	1	2	1	49
Europe	138	2	16	10	166
Latin America	65	0	2	5	72
North America	122	1	1	4	128
Global	**385**	**5**	**22**	**20**	**432**

Table 32 reports what each operator believed with respect to the NDT company they worked for. Of the 5 individual operators that responded 'no', two were the sole responders for their company, but three were contradictory to the responses of other operators from the same NDT company. Only two NDT companies had operators giving consistent responses that there was no emergency plan for site radiography (one of which the operator used only X rays), 5 NDT companies had operators giving consistent responses that they did not know if there was an emergency plan, and for 4 NDT companies the operators did not answer the question.

TABLE 33. RESPONSES TO QUESTION 10b — IF YES TO QUESTION 10, HAVE YOU RECEIVED TRAINING FOR THE ROLES AND RESPONSIBILITIES OF RADIOGRAPHERS IN THAT EMERGENCY PLAN?

	Yes	No	Don't know	No reply	Total
Africa	13	2	0	0	15
Asia-Pacific	39	5	1	0	45
Europe	116	17	3	2	138
Latin America	63	1	1	0	65
North America	107	10	1	4	122
Global	**338**	**35**	**6**	**6**	**385**

I.2.7. Use of collimators and diaphragms during radiography

Questions 11 and 12 of the questionnaire asked the industrial radiographer about his/her use of collimators during gamma radiography and diaphragms during X ray radiography.

TABLE 34. RESPONSES TO QUESTION 11 — DO YOU USE COLLIMATORS WHEN YOU PERFORM GAMMA RADIOGRAPHY?

	Always	Sometimes	Never	Don't know	No reply	Total
Africa	8	7	1	0	1	17
Asia-Pacific	36	11	1	0	1	49
Europe	141	20	1	0	4	166
Latin America	46	22	0	0	4	72
North America	107	17	0	0	4	128
Global	**338**	**77**	**3**	**0**	**14**	**432**

In Table 34, one of the three 'never' responses was for an operator who used Ir, Se and X ray sources in 2009, while the other two did not specify the sources used in 2009. Of the 14 'no replies', 6 were from operators that had replied that they used X ray sources only in 2009.

TABLE 35. RESPONSES TO QUESTION 12 — DO YOU USE DIAPHRAGMS/COLLIMATORS WHEN YOU PERFORM X RAY RADIOGRAPHY?

	Always	Sometimes	Never	Don't know	No reply	Total
Africa	3	4	5	0	5	17
Asia-Pacific	21	15	9	0	4	49
Europe	81	62	14	0	9	166
Latin America	25	27	9	0	11	72
North America	51	25	26	0	26	128
Global	**181**	**133**	**63**	**0**	**55**	**432**

In Table 35, 27 of the 63 'never' responses were for operators who had stated that they used in 2009 gamma sources only. Of the 55 'no replies', 34 were from operators that had stated that they used in 2009 gamma sources only.

I.2.8. Occupational doses and radiographic workload

Question 13 of the questionnaire asked the industrial radiographer about his/her occupational dose, their radiographic workload and the types and strengths of the sources used.

I.2.8.1. Occupational doses

TABLE 36. RESPONSES TO QUESTION 13 — DO YOU KNOW WHAT OCCUPATIONAL RADIATION DOSES YOU RECEIVE?

	Yes	No	Don't know	No reply	Total
Africa	13	2	1	1	17
Asia-Pacific	40	8	1	0	49
Europe	146	14	5	1	166
Latin America	70	0	0	2	72
North America	118	3	2	5	128
Global	**387**	**27**	**9**	**9**	**432**

TABLE 37. RESPONSES TO QUESTION 13a — IF YES TO QUESTION 13, HOW MANY TIMES PER YEAR ARE YOU INFORMED ABOUT YOUR OCCUPATIONAL RADIATION DOSE?

	Replies	No value given	Number of times per year the operator was informed about their occupational dose					
			Mean	Min	Q1	Median	Q3	Max
Africa	13	4	9.3	1	4	12	12	12
Asia-Pacific	34	15	7.6	1	4	5	12	12
Europe	129	37	8.8	0	4	12	12	20
Latin America	49	23	11.4	4	12	12	12	12
North America	93	35	14.4	0	4	12	26	26
Global	**318**	**114**	**10.7**	**0**	**4**	**12**	**12**	**26**

TABLE 38. RESPONSES TO QUESTION 13b(ii) — WHAT IS THE DURATION OF YOUR MONITORING PERIOD?

	Replies	No value given	Monitoring period for occupational dose		
			2weeks	1 month	3 months
Africa	12	5	0	12	0
Asia-Pacific	27	22	0	12	15
Europe	99	67	3	87	9
Latin America	50	22	0	48	2
North America	75	53	42	33	0
Global	**263**	**169**	**45**	**192**	**26**

TABLE 39. RESPONSES TO QUESTION 13b(i) — IF YES TO QUESTION 13, WHAT WAS YOUR TOTAL OCCUPATIONAL DOSE IN 2009?

	Replies	No value given	Annual occupational effective dose 2009 (mSv)					
			Mean	Min	Q1	Median	Q3	Max
Africa	9	8	1.9	0.0	0.0	0.6	2.4	8.5
Asia-Pacific	24	25	4.5	0.0	0.1	1.4	5.3	30.0
Europe	92	74	2.4	0.0	0.1	1.4	4.1	8.9
Latin America	41	31	3.0	0.0	0.3	1.6	2.9	20.0
North America	68	60	5.0	0.0	0.7	3.1	8.0	30.0
Global	**234**	**198**	**3.4**	**0.0**	**0.3**	**1.8**	**4.7**	**30.0**

TABLE 40. RESPONSES TO QUESTION 13b(ii) — IF YES TO QUESTION 13, WHAT WAS THE HIGHEST DOSE YOU RECEIVED IN A GIVEN MONITORING PERIOD IN 2009?

	Replies	No value given	Highest occupational effective dose (mSv) received in a monitoring period in 2009, normalized to a 1 month period					
			Mean	Min	Q1	Median	Q3	Max
Africa	12	5	2.07	0.00	0.23	0.33	2.17	8.79
Asia-Pacific	17	32	0.42	0.00	0.01	0.08	0.26	4.49
Europe	73	93	1.45	0.00	0.11	0.40	1.00	32.00
Latin America	32	40	1.61	0.00	0.22	0.80	1.03	12.30
North America	47	81	1.40	0.00	0.28	1.00	1.90	9.00
Global	**181**	**251**	**1.36**	**0.00**	**0.13**	**0.49**	**1.40**	**32.00**

I.2.8.2. Radiographic workload

TABLE 41. RESPONSES TO QUESTION 13b(iii) — IF YES TO QUESTION 13, WHAT WAS YOUR RADIOGRAPHIC WORKLOAD IN 2009?

	Replies	No value given	Radiographic workload in 2009 — number of films					
			Mean	Min	Q1	Median	Q3	Max
Africa	10	7	2395	30	180	1250	3781	10000
Asia-Pacific	19	30	3165	0	135	400	2000	17000
Europe	112	54	2605	0	200	1000	4000	16000
Latin America	6	66	1130	18	351	675	1713	3111
North America	49	79	2900	0	200	2000	4500	20000
Global	**196**	**236**	**2677**	**0**	**200**	**1000**	**4000**	**20000**

I.2.8.3. Source types and strengths

TABLE 42. RESPONSES TO QUESTION 13b(iv) — DID YOU USE Ir-192 SOURCES IN 2009 AND, IF SO, WHAT TYPICAL ACTIVITY?

	Number of operators:		Ir-192 source activity (Ci)						
	Used Ir-192	No reply	Replies with activity	Mean	Min	Q1	Median	Q3	Max
Africa	7	10	7	52	10	20	45	75	120
Asia-Pacific	32	17	28	44	5	20	30	63	108
Europe	118	48	105	32	4	20	25	40	113
Latin America	56	16	45	35	2	17	30	50	100
North America	109	19	99	61	20	50	60	72	140
Global	**322**	**110**	**284**	**44**	**2**	**25**	**40**	**60**	**140**

TABLE 43. RESPONSES TO QUESTION 13b(iv) — DID YOU USE Ir-192 SOURCES IN 2009 AND, IF SO, WHAT TYPICAL EXPOSURE TIME (SECS) WAS USED?

	Number of operators:		Ir-192 exposure time (secs)						
	Used Ir-192	No reply	Replies with time	Mean	Min	Q1	Median	Q3	Max
Africa	7	10	5	119	30	95	120	150	200
Asia-Pacific	32	17	19	548	25	52	150	270	4000
Europe	118	48	84	159	10	60	95	180	1200
Latin America	56	16	32	291	10	50	120	300	3600
North America	109	19	78	171	7	30	60	120	3600
Global	**322**	**110**	**218**	**216**	**7**	**45**	**80**	**180**	**4000**

TABLE 44. RESPONSES TO QUESTION 13b(iv) — DID YOU USE Se-75 SOURCES IN 2009 AND, IF SO, WHAT TYPICAL ACTIVITY?

	Number of operators:		Se-75 source activity (Ci)						
	Used Se-75	No reply	Replies with activity	Mean	Min	Q1	Median	Q3	Max
Africa	1	16	1	20			20		
Asia-Pacific	8	41	7	56	28	35	55	70	98
Europe	97	69	86	42	10	25	40	50	120
Latin America	26	46	16	22	5	20	20	23	50
North America	16	112	14	47	20	40	46	54	80
Global	**148**	**284**	**124**	**41**	**5**	**25**	**40**	**50**	**120**

TABLE 45. RESPONSES TO QUESTION 13b(iv) — DID YOU USE Se-75 SOURCES IN 2009 AND, IF SO, WHAT TYPICAL EXPOSURE TIME (SECS) WAS USED?

	Number of operators:		Se-75 exposure time (secs)						
	Used Se-75	No reply	Replies with time	Mean	Min	Q1	Median	Q3	Max
Africa	1	16	1	40			40		
Asia-Pacific	8	41	5	96	45	45	50	98	240
Europe	97	69	66	125	5	60	90	164	480
Latin America	26	46	10	98	3	16	40	103	360
North America	16	112	11	133	60	60	120	143	340
Global	**148**	**284**	**93**	**121**	**3**	**60**	**80**	**160**	**480**

TABLE 46. RESPONSES TO QUESTION 13b(iv) — DID YOU USE Co-60 SOURCES IN 2009 AND, IF SO, WHAT TYPICAL ACTIVITY?

	Number of operators:		Co-60 source activity (Ci)						
	Used Co-60	No reply	Replies with activity	Mean	Min	Q1	Median	Q3	Max
Africa	4	13	3	20	14		15		30
Asia-Pacific	1	48	1	110			110		
Europe	21	145	18	32	4	19	24	36	115
Latin America	12	60	10	54	28	60	60	60	60
North America	16	112	16	44	14	29	40	53	80
Global	**54**	**378**	**48**	**41**	**4**	**22**	**36**	**60**	**115**

TABLE 47. RESPONSES TO QUESTION 13b(iv) — DID YOU USE Co-60 SOURCES IN 2009 AND, IF SO, WHAT TYPICAL EXPOSURE TIME (SECS) WAS USED?

	Number of operators:		Co-60 exposure time (secs)						
	Used Co-60	No reply	Replies with time	Mean	Min	Q1	Median	Q3	Max
Africa	4	13	4	233	30	98	150	285	600
Asia-Pacific	1	48	0						
Europe	21	145	10	1616	300	315	1200	2525	4200
Latin America	12	60	9	5653	480	6300	6300	6300	6300
North America	16	112	9	1159	120	300	350	600	7200
Global	**54**	**378**	**32**	**2450**	**30**	**300**	**600**	**6300**	**7200**

TABLE 48. RESPONSES TO QUESTION 13b(iv) — DID YOU USE X RAY SOURCES IN 2009 AND, IF SO, WHAT TYPICAL KILOVOLTAGE?

	Number of operators:		X ray potential (kV)						
	Used X rays	No reply	Replies with kV	Mean	Min	Q1	Median	Q3	Max
Africa	7	10	6	210	150	160	160	175	450
Asia-Pacific	27	22	27	239	160	180	245	295	400
Europe	106	60	96	227	120	198	223	250	450
Latin America	41	31	36	222	100	168	240	250	300
North America	30	98	28	232	110	180	250	265	420
Global	**211**	**221**	**193**	**228**	**100**	**180**	**240**	**250**	**450**

TABLE 49. RESPONSES TO QUESTION 13b(iv) — DID YOU USE X RAY SOURCES IN 2009 AND, IF SO, WHAT TYPICAL TUBE CURRENT?

	Number of operators:		Tube current (mA)						
	Used X rays	No reply	Replies with mA	Mean	Min	Q1	Median	Q3	Max
Africa	7	10	6	5.3	3	3	4	7	10
Asia-Pacific	27	22	27	6.6	3	5	5	5	50
Europe	106	60	96	5.5	3	4	4	5	22
Latin America	41	31	34	6.5	3	5	5	5	13
North America	30	98	27	5.2	2	3	4	7	10
Global	**211**	**221**	**190**	**5.8**	**2**	**4**	**5**	**5**	**50**

TABLE 50. RESPONSES TO QUESTION 13b(iv) — DID YOU USE X RAY SOURCES IN 2009 AND, IF SO, WHAT TYPICAL EXPOSURE TIME (SEC) WAS USED?

	Number of operators:		Exposure time (secs)						
	Used X rays	No reply	Replies with time	Mean	Min	Q1	Median	Q3	Max
Africa	7	10	5	102	40	45	45	180	200
Asia-Pacific	27	22	19	175	1	60	180	300	440
Europe	106	60	79	84	0.3	26	60	110	600
Latin America	41	31	27	376	0.4	40	120	180	3600
North America	30	98	28	123	20.0	60	90	149	390
Global	**211**	**221**	**158**	**152**	**0.3**	**30**	**60**	**152**	**3600**

I.2.9. Access to radiation protection advice

Question 14 of the questionnaire asked the industrial radiographer whether he/she ever discussed radiation protection issues and/or occupational doses with his/her RPO?

TABLE 51. RESPONSES TO QUESTION 14 — DO YOU EVER DISCUSS YOUR RADIATION PROTECTION ISSUES AND/OR YOUR OCCUPATIONAL DOSES WITH YOUR RADIATION PROTECTION OFFICER?

	Yes	No	Don't know	No reply	Total
Africa	14	1	0	2	17
Asia-Pacific	36	10	1	2	49
Europe	112	47	3	4	166
Latin America	58	11	0	3	72
North America	100	21	2	5	128
Global	**320**	**90**	**6**	**16**	**432**

TABLE 52. RESPONSES TO QUESTION 14a — IF YES TO QUESTION 14, APPROXIMATELY HOW MANY TIMES PER YEAR WOULD THIS HAPPEN?

	Replies	No value given	Number of times per year that discussions took place with the RPO					
			Mean	Min	Q1	Median	Q3	Max
Africa	10	4	5.0	1	2	3	9	12
Asia-Pacific	31	5	4.6	1	2	4	5	25
Europe	98	14	5.5	1	2	3	5	75
Latin America	45	13	9.9	1	3	6	12	52
North America	80	20	5.7	1	2	3	9	52
Global	**264**	**56**	**6.2**	**1**	**2**	**4**	**6**	**75**

I.3. ADDITIONAL ANALYSIS OF THE RESPONSES TO THE OPERATOR QUESTIONNAIRE

This Section provides further information, primarily in the form of tables and figures, using the data from the responses given in Section I.2.

I.3.1. Annual occupational doses

Tables 53–54 and Figure 6 present data on the distributions of the annual occupational effective doses of industrial radiographers, as reported by the individual radiographers.

TABLE 53. NUMBERS AND PERCENTAGES OF THE INDUSTRIAL RADIOGRAPHERS WHOSE REPORTED 2009 ANNUAL EFFECTIVE DOSES (D) WERE IN THE FOLLOWING DOSE BANDS — GLOBAL RESULTS

Dose band (mSv)	**Number of industrial radiographers**	**Percentage of industrial radiographers (%)**
D < mdl*	35	15.0
md ≤ D < 1	52	22.2
1 ≤ D < 5	90	38.5
5 ≤ D < 10	35	15.0
0 ≤ D < 15	15	6.4
15 ≤ D < 20	2	0.9
2 0≤ D < 30	3	1.3
30 ≤ D < 50	2	0.9
D ≥ 50	0	0.0
Total	**234**	**100.0**

* mdl = minimum detection limit of the personal dosimetry system.

TABLE 54. PERCENTAGES OF THE INDUSTRIAL RADIOGRAPHERS WHOSE REPORTED 2009 ANNUAL EFFECTIVE DOSES (D) WERE IN THE FOLLOWING DOSE BANDS — REGIONAL RESULTS

	Percentage of industrial radiographers, per region, in the dose bands:								
	Annual effective dose bands (mSv)								
	D<mdl*	**mdl≤D<1**	**1≤D<5**	**5≤D<10**	**10≤D<15**	**15≤D<20**	**20≤D<30**	**30≤D<50**	**D≥50**
Africa	33.3	22.2	33.3	11.1	0.0	0.0	0.0	0.0	0.0
Asia-Pacific	20.8	25.0	25.0	8.3	12.5	4.2	0.0	4.2	0.0
Europe	18.5	20.7	42.4	18.5	0.0	0.0	0.0	0.0	0.0
Latin America	12.2	26.8	43.9	7.3	7.3	0.0	2.4	0.0	0.0
North America	7.4	20.6	35.3	17.6	13.2	1.5	2.9	1.5	0.0
Global	**15.0**	**22.2**	**38.5**	**15.0**	**6.4**	**0.9**	**1.3**	**0.9**	**0.0**

* mdl = minimum detection limit of the personal dosimetry system.

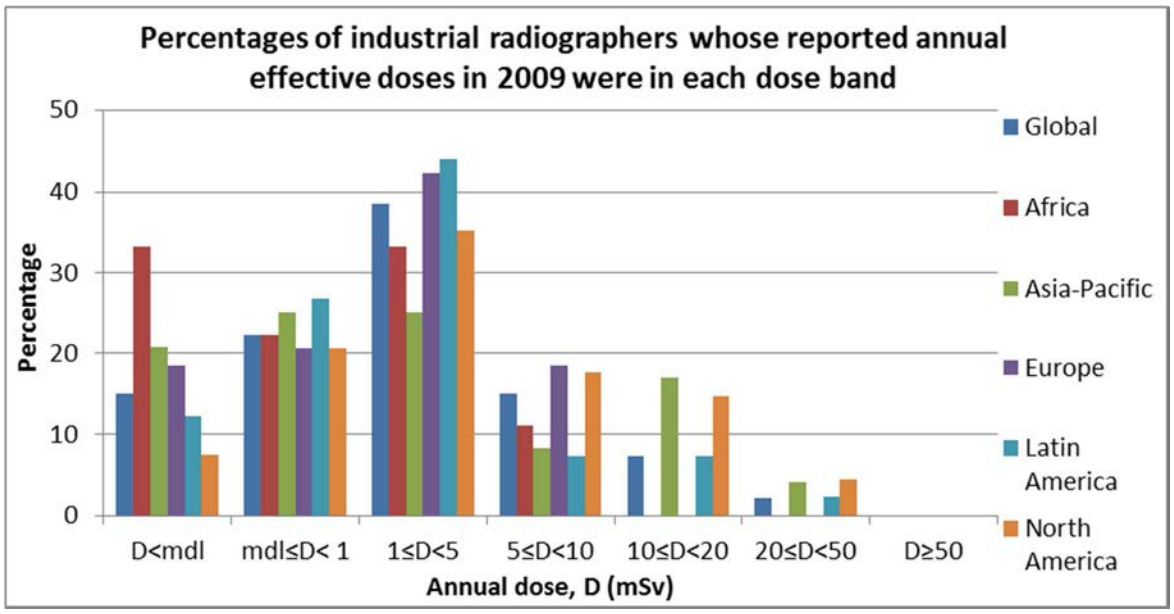

FIG. 6. Results from Table 54 giving percentages of industrial radiographers whose reported 2009 annual effective doses (D) were in the given dose bands. Note, mdl means minimum detection limit of the personal dosimetry system.

I.3.2. Highest monthly doses

The reported highest occupational doses in a given monitoring period, normalized to a one month period, were analyzed further to obtain the distribution of these doses, as given in Table 55 and Figure 7. Statistics on the ratio of the highest occupational effective dose received in a monitoring period in 2009, normalized to a one month period, to the annual occupational effective dose are given in Table 56. For a consistent workload and occupational exposure conditions, one would expect *a priori* a mean of ratio of about 0.083. That the means were significantly higher than this value emphasizes the uneven nature of occupational exposure in industrial radiography. Figure 8 presents annual effectives doses as a function of the highest monthly dose.

TABLE 55. NUMBER OF INDUSTRIAL RADIOGRAPHERS WHOSE (NORMALIZED) MAXIMUM MONTHLY DOSE (D_m) IN 2009 WAS IN THE GIVEN DOSE BANDS

Number of industrial radiographers whose reported highest effective dose in a month, D_m, was in the monthly dose bands (mSv):						
$D_m < 1$	$1 \leq D_m < 2.5$	$2.5 \leq D_m < 5$	$5 \leq D_m < 10$	$10 \leq D_m < 20$	$20 \leq D_m < 50$	$D_m \geq 50$
122	34	18	3	3	1	0

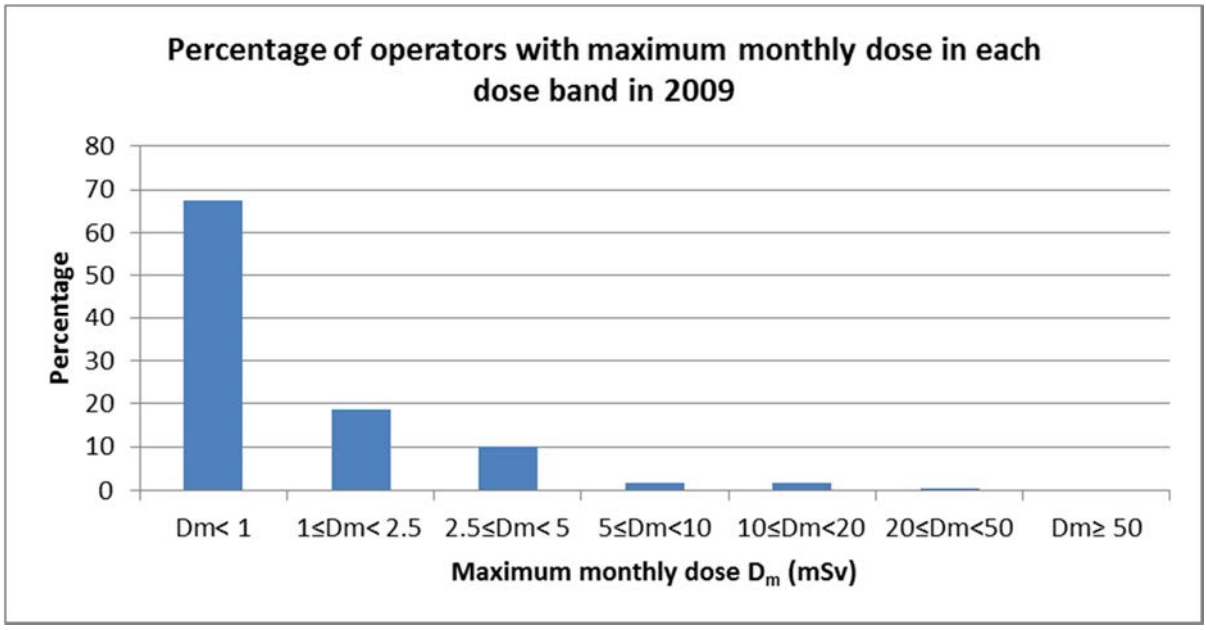

FIG. 7. Results from Table 55, giving percentages of industrial radiographers whose reported maximum monthly dose, D_m, in 2009 was in the given dose bands.

TABLE 56. RATIOS OF THE HIGHEST OCCUPATIONAL EFFECTIVE DOSE RECEIVED IN A MONITORING PERIOD IN 2009, NORMALIZED TO A ONE MONTH PERIOD, TO THE ANNUAL OCCUPATIONAL EFFECTIVE DOSE IN 2009

	Replies	No value given	Ratio of highest occupational effective dose received in a monitoring period in 2009, normalized to a 1 month period, to the annual occupational dose in 2009					
			Mean	Min	Q1	Median	Q3	Max
Africa	6	11	0.48	0.13	0.23	0.33	0.66	1.00**
Asia-Pacific	13	36	0.19	0.05*	0.09	0.15	0.29	0.39
Europe	60	106	0.30	0.09	0.14	0.23	0.45	1.00**
Latin America	28	44	0.49	0.02*	0.27	0.40	0.75	1.00**
North America	42	86	0.42	0.04*	0.18	0.28	0.53	1.71**
Global	**149**	**283**	**0.36**	**0.02***	**0.15**	**0.27**	**0.45**	**1.71****

* In a very few cases the reported highest monthly dose was less than one-twelfth of the annual dose — logically not possible, but perhaps simply reflecting errors in recalling past doses.
** The normalization of two-week monitoring periods to a one month monitoring period has led to some instances where the extrapolated monthly dose equaled or exceeded the annual dose. In no case did the actual highest dose per actual monitoring period exceed the annual dose.

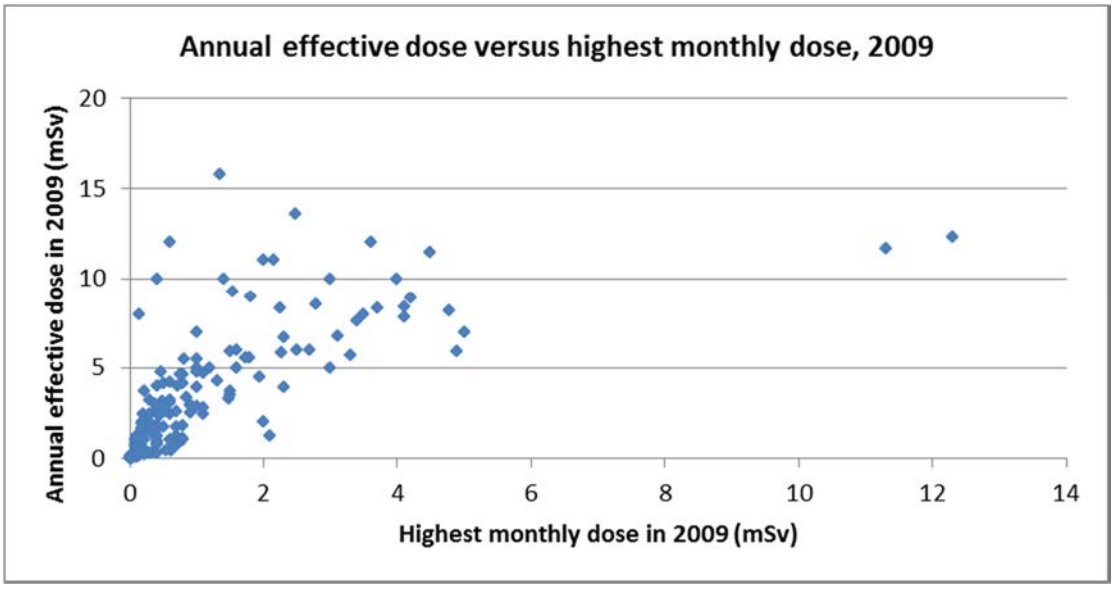

FIG. 8. Annual effective dose versus highest monthly dose, for reported values in 2009. There were 149 data points (as in Table 56). The coefficient of correlation was 0.67.

I.3.3. Workloads and occupational doses

Figure 9 gives the distribution of reported annual effective doses of industrial radiographers as a function of their reported annual number of radiographic exposures.

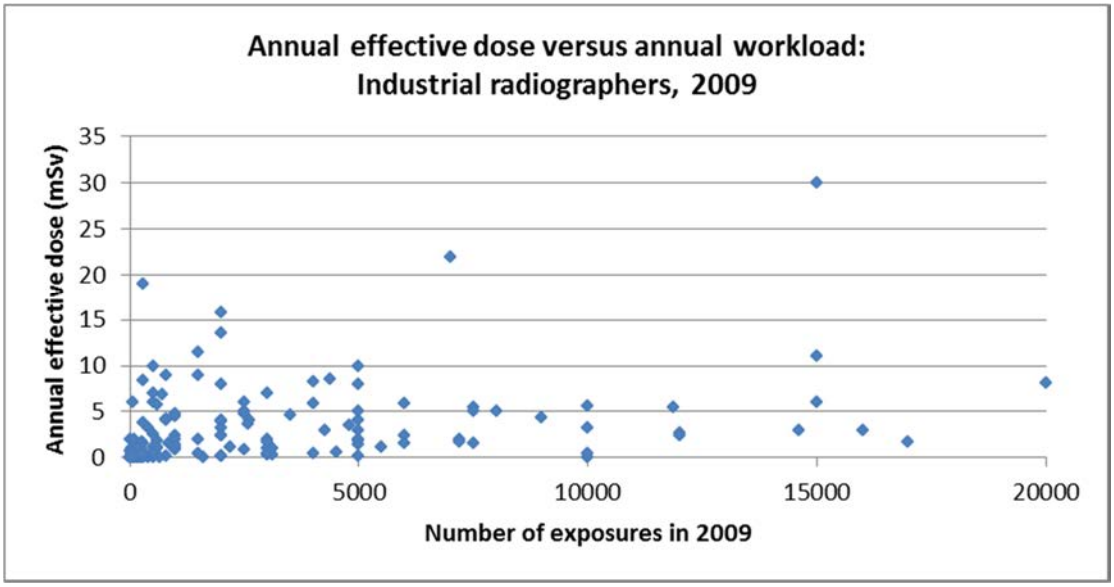

FIG. 9. Annual effective dose versus annual workload, for reported values in 2009. There were 150 data points, and the coefficient of correlation was 0.34.

Values of occupational effective dose per radiographic exposure were derived, based on reported annual doses and workloads in 2009. Table 57 presents these values for all responding industrial radiographers who provided data, while Table 58 excludes those radiographers who performed fewer than 100 exposures in the year.

TABLE 57. OCCUPATIONAL EFFECTIVE DOSE PER EXPOSURE, BASED ON REPORTED ANNUAL DOSES AND ANNUAL WORKLOADS IN 2009

	Derived values	Effective dose per exposure (µSv/exposure)							No data given
		Mean	SD	Min	Q1	Median	Q3	Max	
Africa	7	2.0	1.8	0.0	1.0	2.0	2.5	5.3	10
Asia-Pacific	14	6.3	17.2	0.0	0.1	1.1	1.9	65.5	35
Europe	79	3.7	12.0	0.0	0.2	0.5	2.2	100.0	87
Latin America	6	6.4	14.6	0.0	0.0	0.2	1.5	36.1	66
North America	35	7.0	17.5	0.1	0.8	1.3	5.5	100.0	93
Global	**141**	**4.8**	**13.9**	**0.0**	**0.2**	**0.9**	**2.4**	**100.0**	**291**

TABLE 58. OCCUPATIONAL EFFECTIVE DOSE PER EXPOSURE, BASED ON REPORTED ANNUAL DOSES AND ANNUAL WORKLOADS IN 2009, EXCLUDING VERY LOW WORKLOADS — LESS THAN 100 EXPOSURES PER YEAR

	Derived values	Effective dose per exposure (μSv/exposure)							No data given
		Mean	SD	Min	Q1	Median	Q3	Max	
Africa	7	2.0	1.8	0.0	1.0	2.0	2.5	5.3	10
Asia-Pacific	13	6.8	17.8	0.0	0.2	1.2	2.0	65.5	36
Europe	72	2.0	3.3	0.0	0.2	0.5	2.1	14.0	94
Latin America	5	0.5	0.8	0.0	0.0	0.1	0.3	1.9	67
North America	32	4.0	6.5	0.1	0.7	1.3	3.6	27.8	96
Global	**129**	**2.9**	**7.0**	**0.0**	**0.3**	**0.9**	**2.3**	**65.5**	**303**

I.3.4. Occupational doses per exposure

The following sub-sections present data on the effect of the radiation source being used, its activity, the use of collimation, the level of NDT training, and the number of incidents on the derived values of occupational effective dose per radiographic exposure.

I.3.4.1. Gamma sources versus X ray sources

TABLE 59. STATISTICS FOR THE DERIVED OCCUPATIONAL EFFECTIVE DOSE PER EXPOSURE FOR RADIOGRAPHERS WHO WERE USING GAMMA SOURCES ONLY, X RAY SOURCES ONLY, OR BOTH, AND WHOSE WORKLOAD WAS 100 EXPOSURES OR MORE PER YEAR IN 2009

	Occupational effective dose per exposure (μSv/exp):		
	Gamma sources only	X ray sources only	Both sources
No. of data	43	15	70
Mean	3.85	2.05	2.59
SD	10.09	3.56	5.04
Min	0.00	0.00	0.00
Q1	0.37	0.09	0.23
Median	1.01	0.48	0.70
Q3	3.07	1.93	2.06
Max	65.52	12.67	27.80

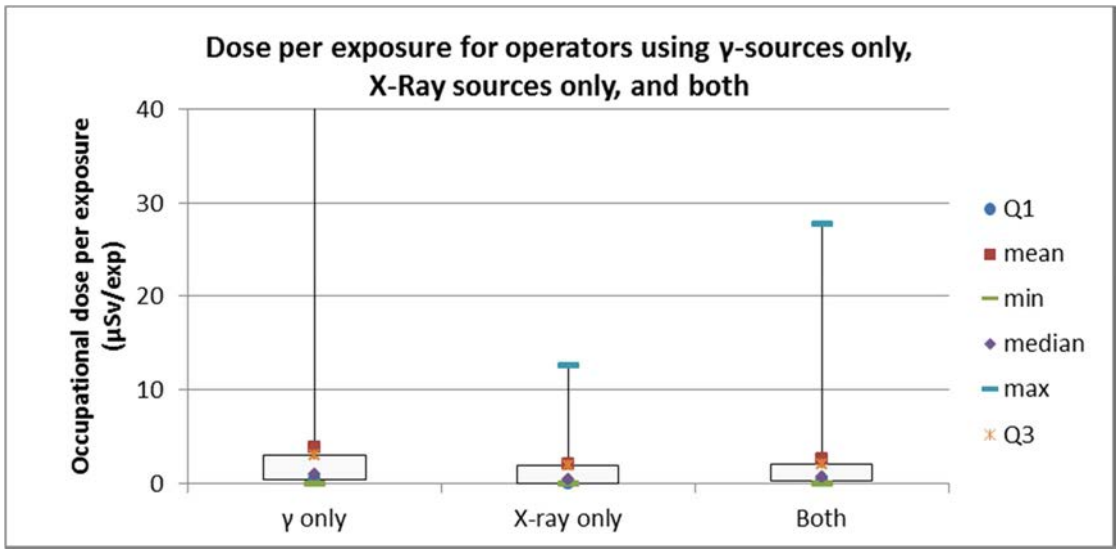

FIG. 10. From the data in Table 59, distribution statistics for the derived occupational effective dose per exposure for radiographers who were using gamma sources only, X ray sources only or both, and whose workload was 100 exposures or more per year in 2009.

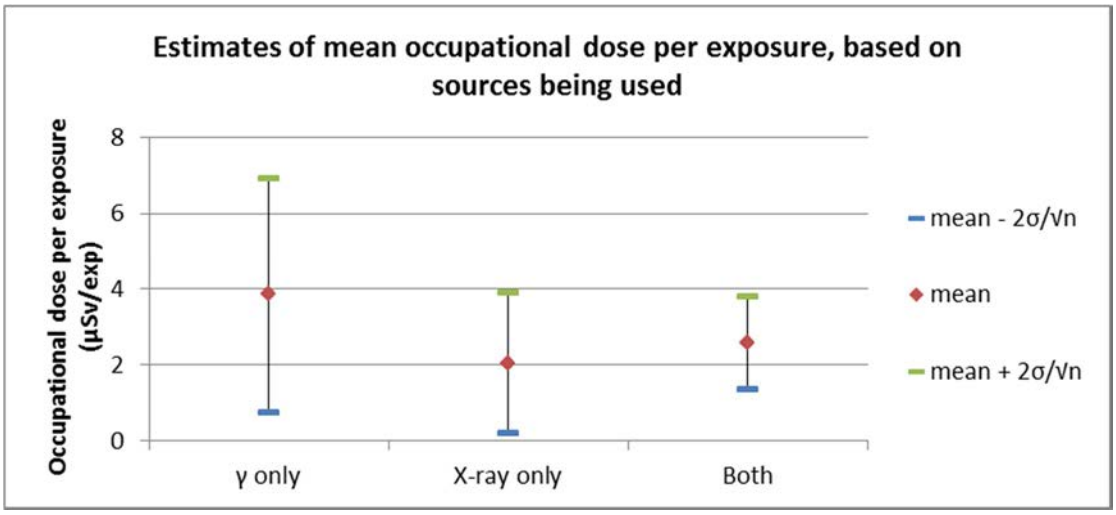

FIG. 11. Based on the data in Table 59, the estimates of mean occupational effective dose per exposure as a function of the sources being used. The bars are two times the standard error for the estimates of the mean. There was no statistically significant difference between the means of the gamma-only and X ray only distributions.

I.3.4.2. Iridium-192 source activity

Iridium-192 was the most commonly used source by the responding industrial radiographers. Figures 12–13 present data for annual effective dose versus the Ir-192 source activity and effective dose per exposure versus the Ir-192 source activity for all radiographers who reported that they used Ir-192 sources and who provided the necessary data. Figures 14–15 present data for those radiographers who worked with Ir-192 sources only.

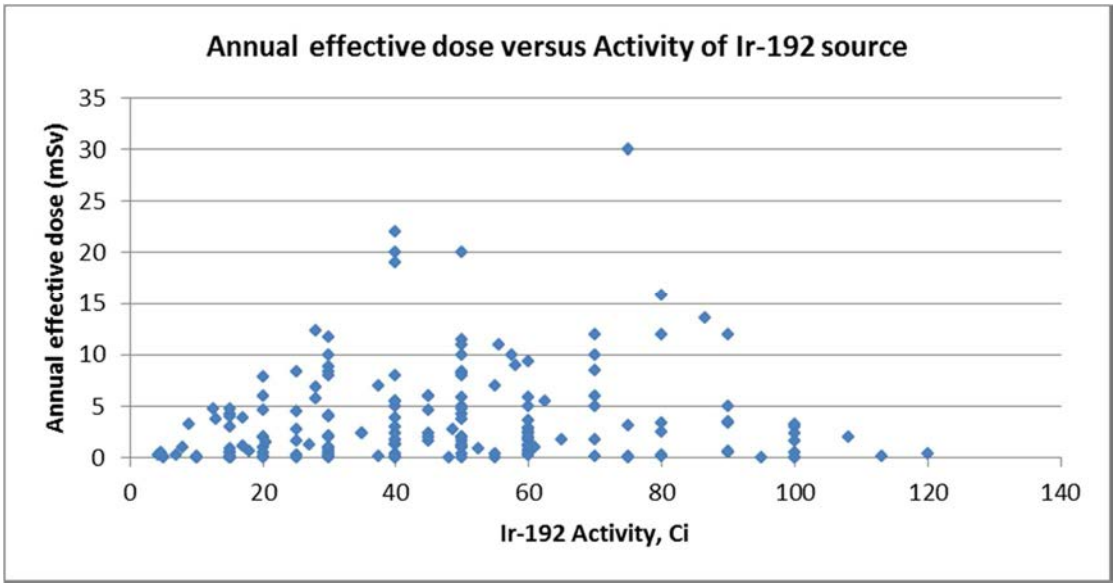

FIG. 12. Annual effective dose versus Ir-192 source activity for radiographers who reported that they used Ir-192 sources and the typical activity was specified. There were 178 data points, and the coefficient of correlation was 0.12.

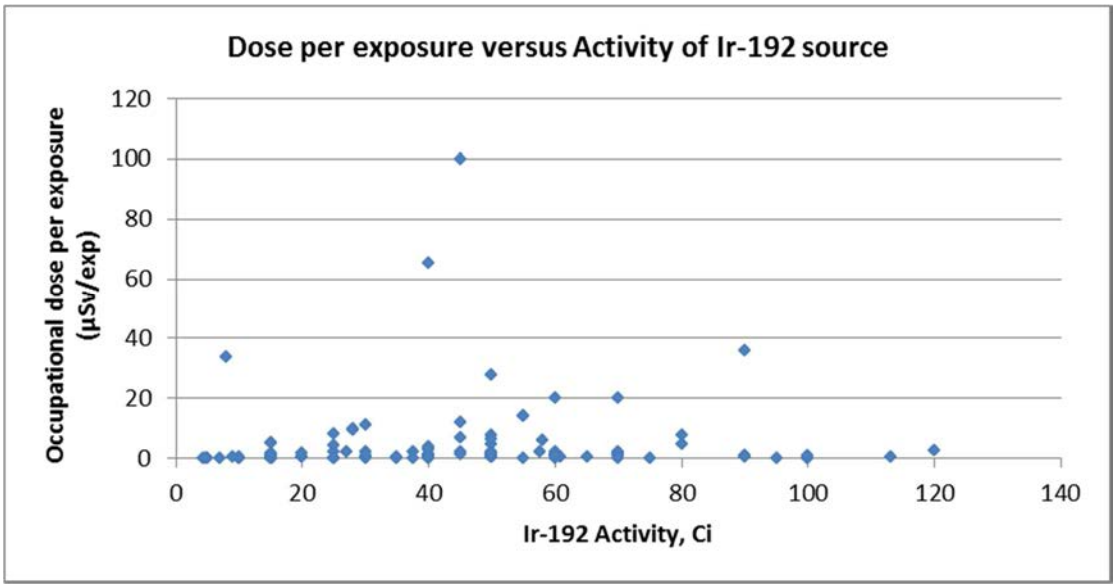

FIG. 13. Effective dose per exposure versus Ir-192 source activity for radiographers who reported that they used Ir-192 sources, the typical activity was specified, and the annual workload was given. There were 111 data points, and the coefficient of correlation was 0.05.

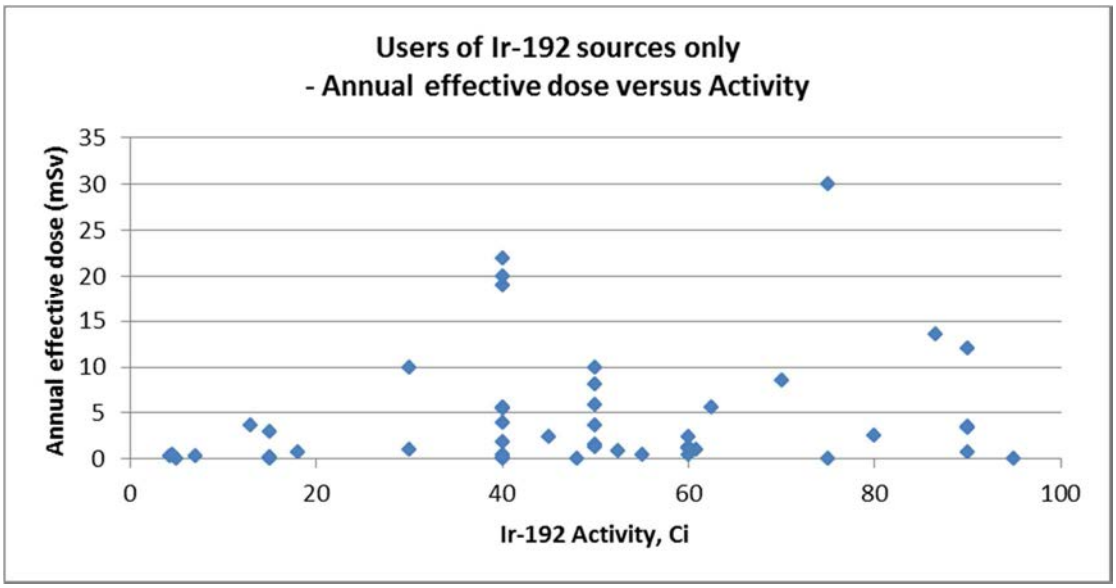

FIG. 14. Annual effective dose versus Ir-192 source activity for radiographers who reported that they used only Ir-192 sources and the typical activity was specified. There were 49 data points, and the coefficient of correlation was 0.21.

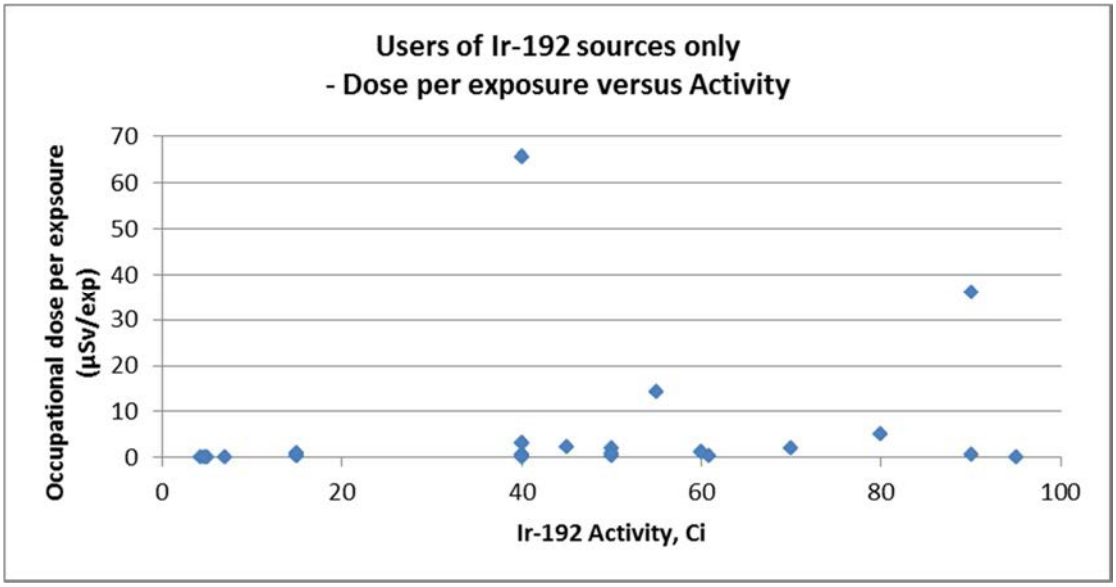

FIG. 15. Effective dose per exposure versus Ir-192 source activity for radiographers who reported that they used only Ir-192 sources, the typical activity was specified, and the annual workload was given. There were 28 data points, and the coefficient of correlation was 0.19.

I.3.4.3. Use of collimation – gamma radiography

Table 60 and Figures 16–17 present data on the effect of the use of collimation when performing gamma radiography on the occupational effective dose per radiographic exposure.

TABLE 60. DISTRIBUTION STATISTICS FOR THE DERIVED OCCUPATIONAL EFFECTIVE DOSE PER EXPOSURE FOR RADIOGRAPHERS, DEPENDING ON THEIR USE OF COLLIMATORS WITH GAMMA SOURCES IN 2009

	Effective dose per exposure (µSv/exp):	
	Always used collimators	Sometimes used collimators
No. of data	106	18
Mean	3.3	4.2
SD	8.3	4.4
Min	0.0	0.0
Q1	0.3	1.3
Median	0.8	2.5
Q3	2.0	5.2
Max	65.9	14.3

Data for radiographers whose workload was less than 100 exposures per year in 2009 were excluded. Only 4 radiographers reported that they never used collimation with gamma sources.

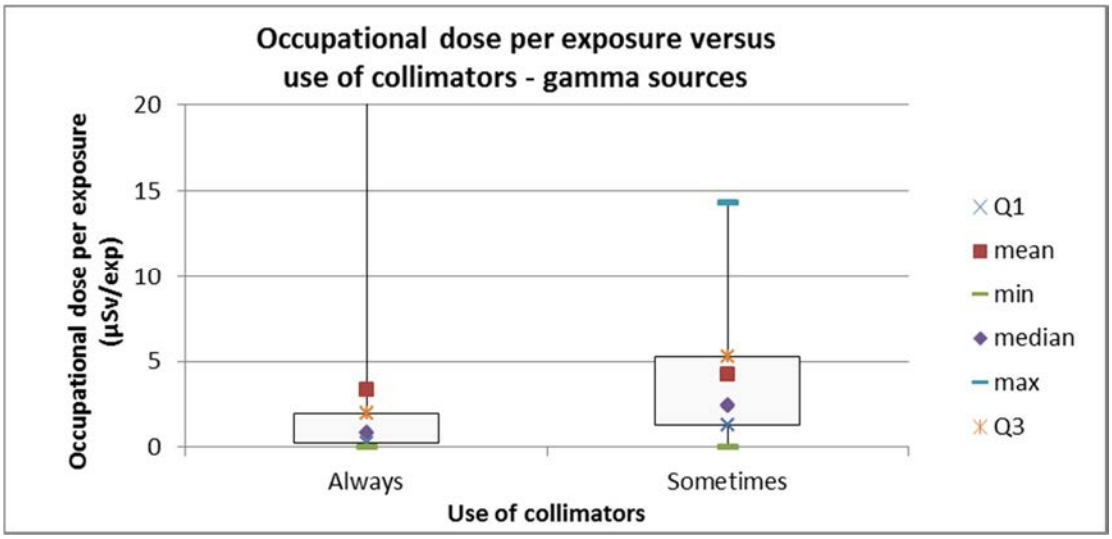

FIG. 16. From the data in Table 60, the distribution statistics for the derived occupational effective dose per exposure for radiographers depending on their use of collimators with gamma sources.

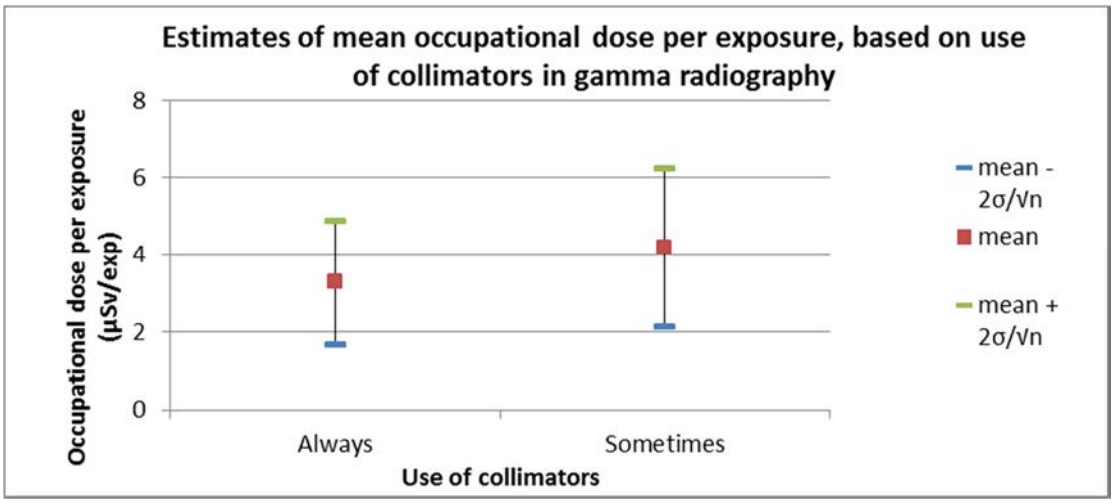

FIG. 17. From the data in Table 60, estimates of the mean occupational effective dose per exposure as a function of the use of collimation for gamma sources. The bars are two times the standard error for the estimates of the mean. There was no statistically significant difference between the means of the distributions for those that always used collimation versus those that only sometimes used collimation.

I.3.4.4. Use of collimation —X ray radiography

Table 61 and Figures 18–19 present data on the effect of the use of collimation when performing X ray radiography on the occupational effective dose per radiographic exposure.

TABLE 61. DISTRIBUTION STATISTICS FOR THE DERIVED OCCUPATIONAL EFFECTIVE DOSE PER EXPOSURE FOR RADIOGRAPHERS, DEPENDING ON THEIR USE OF COLLIMATORS WITH X RAY SOURCES IN 2009

	Effective dose per exposure (μSv/exp):		
	Always used collimators	Sometimes used collimators	Never used collimators
No. of data	58	40	20
Mean	3.2	1.9	5.6
SD	5.1	3.2	14.8
Min	0.0	0.0	0.0
Q1	0.4	0.2	0.2
Median	1.4	0.6	0.9
Q3	2.9	1.6	2.1
Max	27.8	14.0	65.5

Data for radiographers whose workload was less than 100 exposures per year in 2009 were excluded.

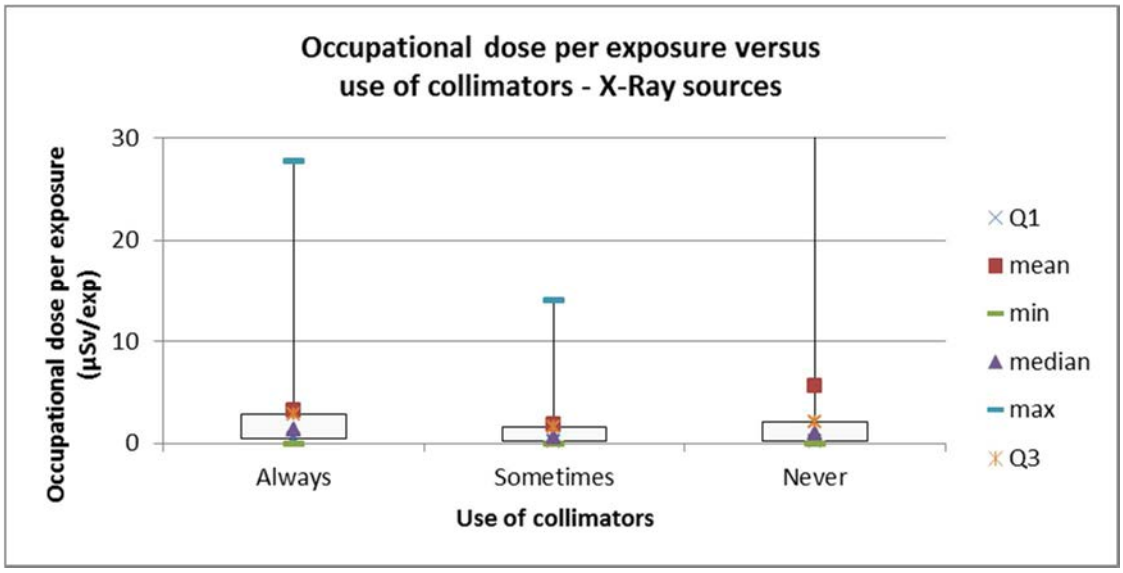

FIG. 18. From the data in Table 61, the distribution statistics for the derived occupational effective dose per exposure for radiographers depending on their use of collimators with X ray sources.

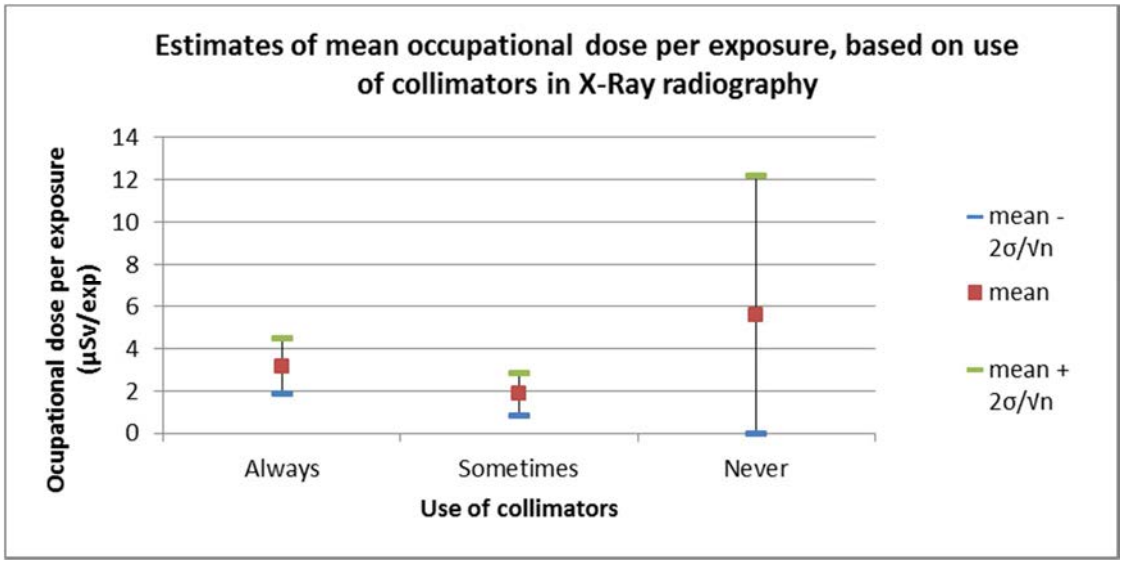

FIG. 19. From the data in Table 61, the estimates of mean occupational effective dose per exposure as a function of the use of collimation for X ray sources. The bars are two times the standard error for the mean estimates. There was no statistically significant difference between the means of the distributions for those that always used collimation versus those that never used collimation.

I.3.4.5. Level of NDT training

Tables 62–63 and Figures 20–21 present data on the effect of the level of the radiographer's NDT training on the occupational effective dose per radiographic exposure.

TABLE 62. DISTRIBUTION STATISTICS FOR THE ANNUAL OCCUPATIONAL EFFECTIVE DOSE FOR RADUIOGRAPHERS AS A FUNCTION OF THEIR LEVEL OF NDT TRAINING

	Annual occupational effective dose (mSv):		
	NDT level 1	NDT level 2	NDT level 3
No. of data	64	120	39
Mean	3.8	3.6	3.2
SD	4.9	4.7	5.0
Min	0.0	0.0	0.0
Q1	0.4	0.2	0.5
Median	2.3	2.0	1.2
Q3	5.2	5.0	2.8
Max	30.0	30.0	20.0

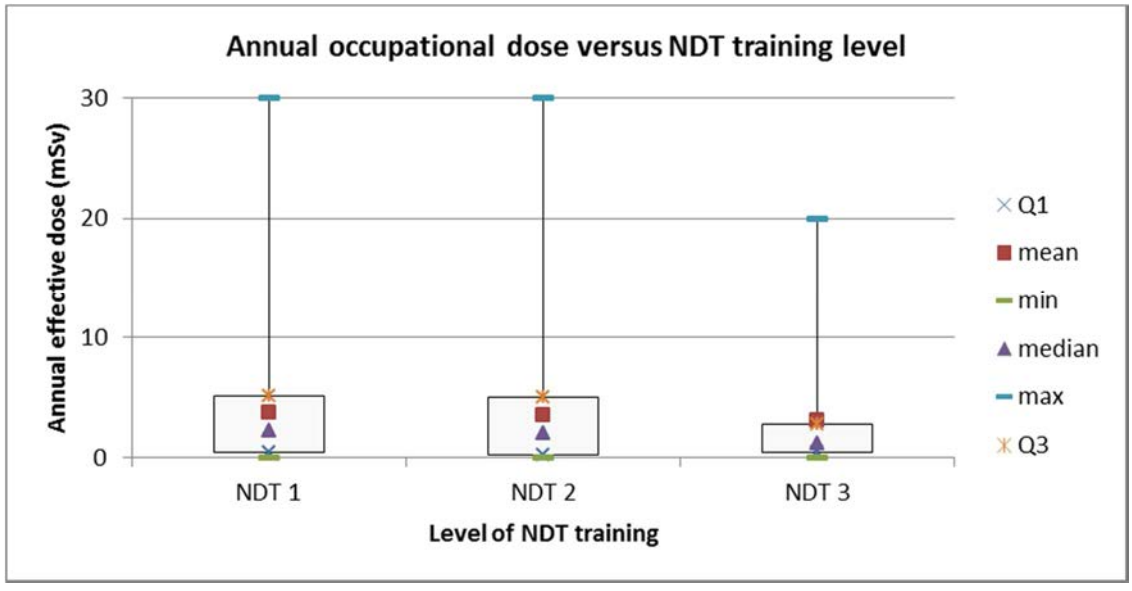

FIG. 20. From the data in Table 62, the distribution statistics for the annual effective dose of radiographers depending on their level of NDT training.

TABLE 63. DISTRIBUTION STATISTICS FOR THE DERIVED OCCUPATIONAL EFFECTIVE DOSE PER EXPOSURE FOR RADIOGRAPHERS AS A FUNCTION OF THEIR LEVEL OF NDT TRAINING. DATA FOR RADIOGRAPHERS WHOSE WORKLOAD WAS LESS THAN 100 EXPOSURES YEAR IN 2009 WERE EXCLUDED

	Occupational effective dose per exposure(μSv/exp):		
	NDT level 1	NDT level 2	NDT level 3
No. of data	21	76	26
Mean	3.7	2.2	4.1
SD	6.2	3.7	12.7
Min	0.0	0.0	0.0
Q1	0.5	0.3	0.2
Median	1.0	0.8	1.2
Q3	5.0	2.0	2.3
Max	27.8	20.0	65.5

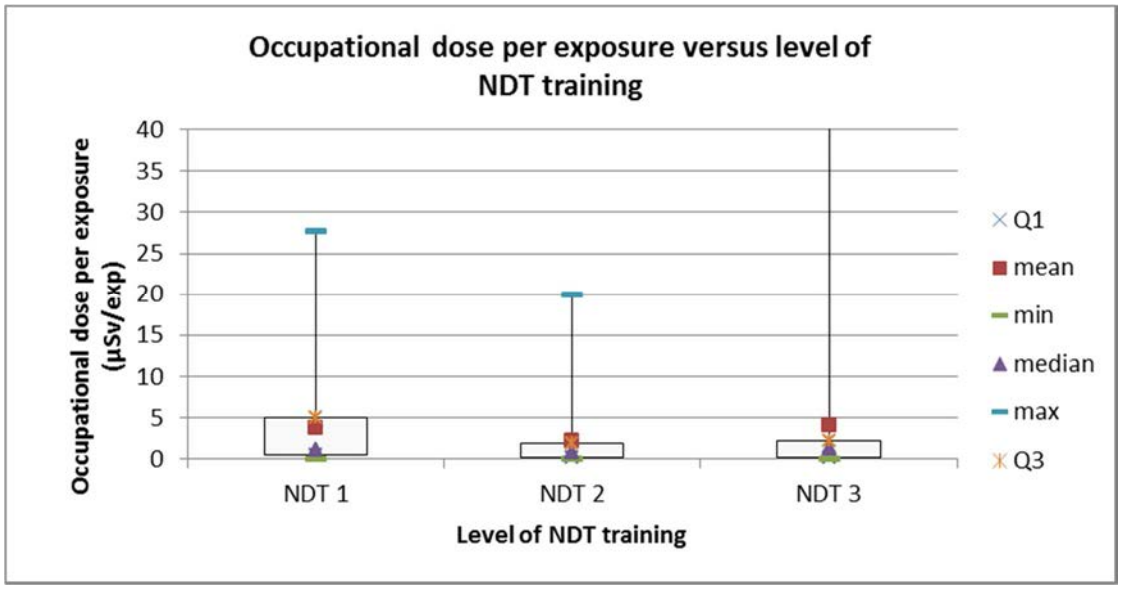

FIG. 21. From the data of Table 63, the distribution statistics for the derived occupational effective dose per exposure for radiographers depending on their level of NDT training, excluding very low workloads —fewer than 100 exposures per year.

I.3.4.6. Number of accidents, near misses and deviations

Tables 64–66 and Figures 22–25 present data on occupational doses of radiographers and their reported number of accidents, near misses and deviations.

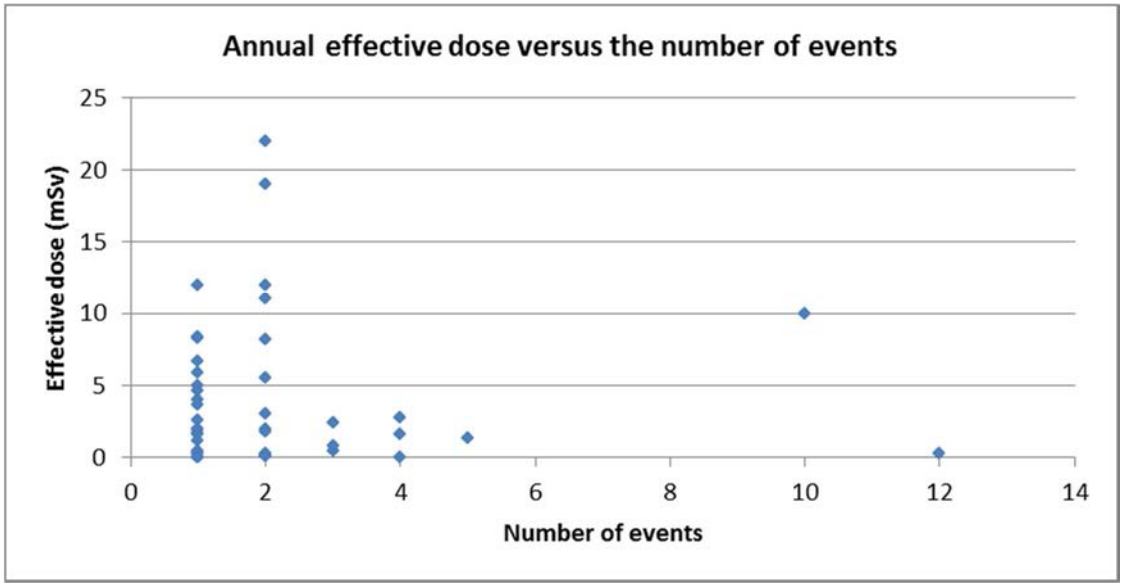

FIG. 22. Annual occupational effective dose (2009) versus the total number of events (accidents, near misses and deviations) reported by the radiographer in the questionnaire for the last 5 years. There was no correlation.

TABLE 64. ANNUAL OCCUPATIONAL EFFECTIVE DOSES FOR 2009 ANALYZED ON THE BASIS OF WHETHER RADIOGRAPHERS SAID THAT THEY HAD OR NOT HAD ACCIDENTS, NEAR MISSES OR DEVIATIONS IN THE LAST 5 YEARS

	Annual occupational effective dose, 2009 (mSv)							
	All events		Accidents only		Near misses only		Deviations only	
	None	≥ 1 event	None	≥ 1 event	None	≥ 1 event	None	≥ 1 event
No. of data	186	43	225	6	211	19	199	30
Mean	3.3	4.1	3.4	3.0	3.5	3.4	3.4	4.0
SD	4.7	5.1	4.8	3.0	4.7	5.1	4.7	4.9
Min	0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0
Q1	0.2	0.4	0.3	0.9	0.2	0.9	0.3	0.3
Median	1. 7	2.0	1.7	2.7	1.7	2.0	1.8	1.7
Q3	4.6	5.7	4.7	3.7	4.9	2.9	4.5	6.4
Max	30.0	22.0	30.0	8.3	30.0	22.0	30.0	19.0

TABLE 65. THE HIGHEST MONTHLY OCCUPATIONAL EFFECTIVE DOSE IN 2009 ANALYZED ON THE BASIS OF WHETHER RADIOGRAPHERS SAID THAT THEY HAD OR NOT HAD ACCIDENTS, NEAR MISSES OR DEVIATIONS IN THE LAST 5 YEARS

	Highest monthly effective dose in 2009 (mSv)							
	All events		Accidents only		Near misses only		Deviations only	
	None	≥ 1 event	None	≥ 1 event	None	≥ 1 event	None	≥ 1 event
No. of data	144	33	173	5	164	14	153	24
Mean	1.4	1.2	1.3	1.0	1.4	0.9	1.4	1.1
SD	3.3	1.4	3.0	0.8	3.1	1.3	3.2	1.3
Min	0.0	0.0	0.0	0.01	0.0	0.01	0.0	0.0
Q1	0.1	0.2	0.1	0.7	0.1	0.2	0.1	0.3
Median	0.5	0.5	0.5	0.7	0.5	0.4	0.5	0.5
Q3	1.3	1.8	1.4	1.1	1.4	0.9	1.3	1.6
Max	32.0	4.9	32.0	2.2	32.0	4.9	32.0	4.8

TABLE 66. OCCUPATIONAL EFFECTIVE DOSE PER EXPOSURE ANALYZED ON THE BASIS OF WHETHER RADIOGRAPHERS SAID THAT THEY HAD OR NOT HAD ACCIDENTS, NEAR MISSES OR DEVIATIONS IN THE LAST 5 YEARS

	Occupational effective dose per exposure (µSv/exp)							
	All events		Accidents only		Near misses only		Deviations only	
	None	≥ 1 event	None	≥ 1 event	None	≥ 1 event	None	≥ 1 event
No. of data	115	23	136	3	128	11	122	16
Mean	3.8	5.6	4.0	9.9	4.3	1.6	3.9	5.9
SD	10.7	14.4	11.3	15.6	11.8	1.5	10.6	16.3
Min	0.0	0.05	0.0	0.2	0.0	0.2	0.0	0.05
Q1	0.2	0.3	0.3	-	0.2	0.3	0.2	0.4
Median	0.9	0.6	0.9	1.5	0.9	1.4	1.0	0.6
Q3	2.4	2.2	2.4	-	2.4	2.5	2.4	2.2
Max	100.0	65.5	100.0	27.8	100.0	4.5	100.0	65.5

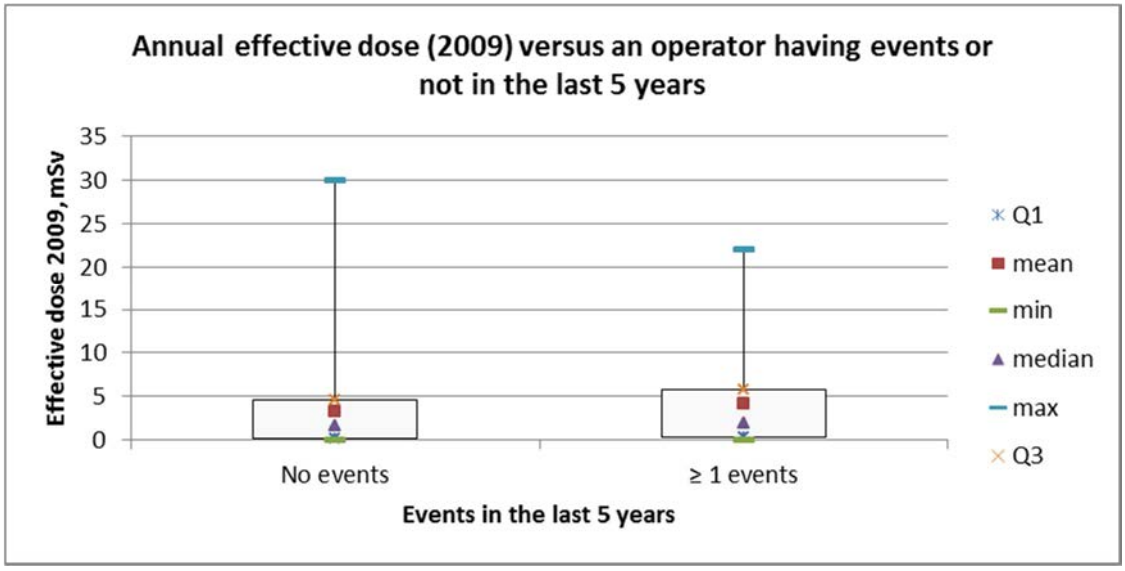

FIG. 23. Distribution statistics for the annual occupational effective doses for 2009 analysed on the basis of whether radiographers said that they had had or not had any events (accidents, near misses or deviations) in the last 5 years. Data are from Table 64.

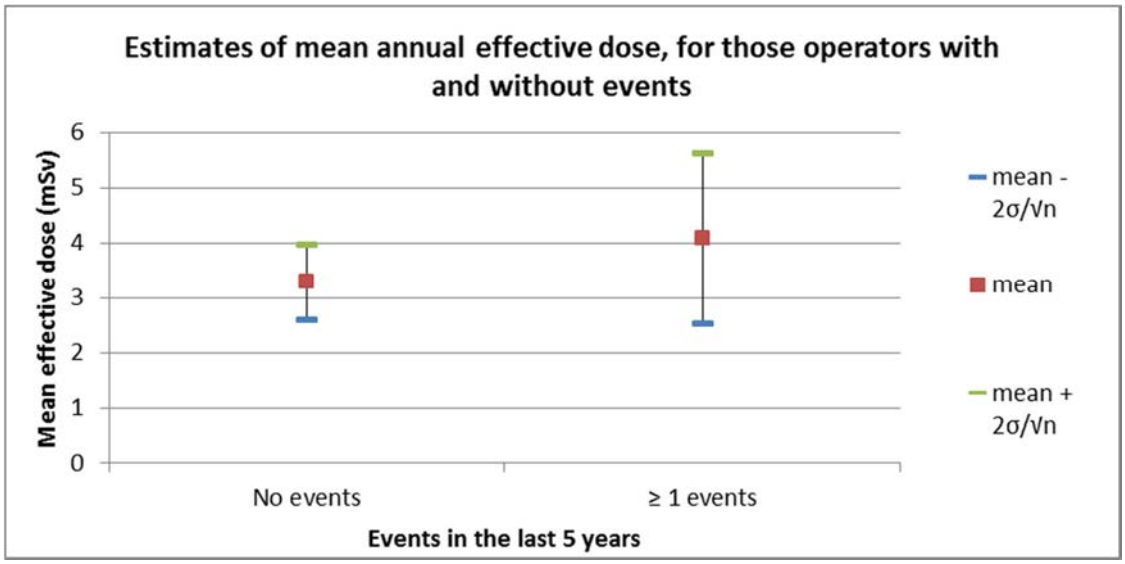

FIG. 24. Estimates of mean annual effective dose as a function of whether radiographers said that they had had or not had any events (accidents, near misses or deviations) in the last 5 years. The bars are two times the standard error for the mean estimates. There was no statistically significant difference between the means of the distributions for those that said they had had no events and those that said that had had some events.

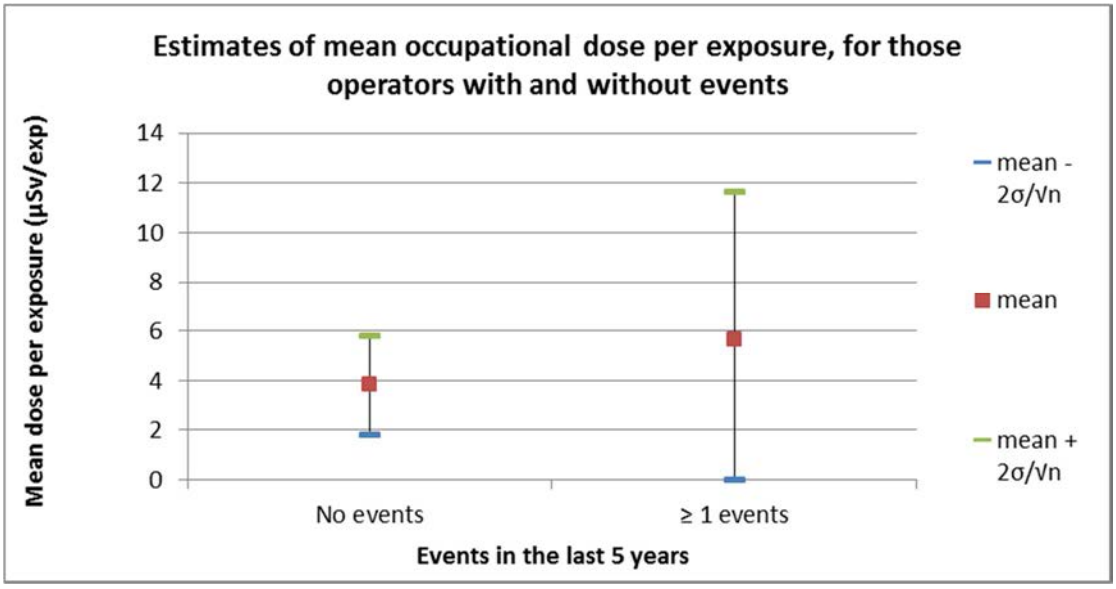

FIG. 25. Estimates of mean occupational effective dose per exposure as a function of whether radiographers said that they had had or not had any events (accidents, near misses or deviations) in the last 5 years. The bars are two times the standard error for the mean estimates. There was no statistically significant difference between the means of the distributions for those that said they had had no events and those that said that had had some events.

APPENDIX II. DETAILED RESULTS OF THE QUESTIONNAIRE ON OCCUPATIONAL EXPOSURE IN INDUSTRIAL RADIOGRAPHY ADDRESSED TO OPERATING COMPANIES

II.1. INTRODUCTION

The principal findings from the operating company questionnaire are given in Section 2.3, together with results from the other questionnaires. Appendix II gives additional data in the form of tables and figures. Many of the table headings refer to a specific question number in the operating company questionnaire. For reference, the questions from the questionnaire are given in Appendix IV.

The term 'operating company' in the context of the questionnaire is synonymous with the term 'NDT company'. Similarly, as in Appendix I, the term 'operator' is synonymous with 'radiographer'. The abbreviation RP is often used for 'radiation protection' in the following tables and figures. In many of the tables and figures, 'Min' means minimum, 'Q1' means first quartile, 'Q3' means third quartile, 'Max' means maximum, and 'SD' means standard deviation.

Note, not all questions were answered by all responders.

II.2. NUMBER OF NDT COMPANY RESPONSES

TABLE 67. DETAILS OF RESPONSES TO THE NDT COMPANY QUESTIONNAIRE

	Number of NDT Companies	Number of countries
Africa	7	4
Asia-Pacific	33	6
Europe	28	13
Latin America	19	4
North America	8	2
Global	**95**	**29**

II.3. QUALIFICATIONS AND TRAINING OF INDUSTRIAL RADIOGRAPHERS IN RADIATION PROTECTION

TABLE 68. RESPONSES TO QUESTION 1 — DOES YOUR COMPANY PROVIDE OR FACILITATE RADIATION PROTECTION TRAINING FOR ITS RADIOGRAPHERS?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	0	7
Asia-Pacific	33	0	0	0	33
Europe	26	2	0	0	28
Latin America	19	0	0	0	19
North America	8	0	0	0	8
Global	**93**	**2**	**0**	**0**	**95**

As per the questionnaire instructions (see Appendix IV), for Tables 69–82 an unmarked option on a returned questionnaire was interpreted as a 'no' response.

II.3.1. Initial radiation protection training

TABLE 69. RESPONSES TO QUESTION 1a(i) — IF YES TO QUESTION 1, DO YOU PROVIDE, WITHIN THE COMPANY, INITIAL RADIATION PROTECTION TRAINING (THEORY) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION?

	Yes	No	Duration of initial training, theory, within the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	3	4	3	14.0	8	-	10	-	24
Asia-Pacific	26	7	26	12.7	1	2	8	19	48
Europe	15	11	15	7.3	1	2	4	8	30
Latin America	16	3	15	55.3	4	26	60	80	160
North America	7	1	7	14.1	3	4	8	20	40
Global	**67**	**26**	**66**	**21.3**	**1**	**3**	**8**	**30**	**160**

TABLE 70. RESPONSES TO QUESTION 1a(ii) — IF YES TO QUESTION 1, DO YOU PROVIDE, WITHIN THE COMPANY, INITIAL RADIATION PROTECTION TRAINING (PRACTICAL) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION?

	Yes	No	Duration of initial training, practical, within the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	3	4	3	10.7	6	-	10	-	16
Asia-Pacific	23	10	23	13.1	1	2	8	20	48
Europe	16	10	16	17.5	2	2	6	30.5	100
Latin America	15	4	14	24.2	2	9.8	20	35.0	80
North America	7	1	7	49.0	1	6	10	10	300
Global	**64**	**29**	**63**	**20.6**	**1**	**2.5**	**8**	**22**	**300**

TABLE 71. RESPONSES TO QUESTION 1a(v) — IF YES TO QUESTION 1, DO YOU PROVIDE, OUTSIDE THE COMPANY, INITIAL RADIATION PROTECTION TRAINING (THEORY) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION?

	Yes	No	Duration of initial training, theory, outside the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	3	4	3	35.0	20	-	40	-	45
Asia-Pacific	19	14	18	26.9	1	8	20	40	80
Europe	22	4	21	27.0	5	20	30	35	46
Latin America	10	9	10	45.0	16	21	47.5	58.8	80
North America	6	2	6	38.3	30	40	40	40	40
Global	**60**	**33**	**58**	**31.7**	**1**	**17**	**30**	**40**	**80**

TABLE 72. RESPONSES TO QUESTION 1a(vi) — IF YES TO QUESTION 1, DO YOU PROVIDE, OUTSIDE THE COMPANY, INITIAL RADIATION PROTECTION TRAINING (PRACTICAL) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION?

	Yes	No	Duration of initial training, practical, outside the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	2	5	2	42.5	40	41.3	42.5	43.8	45
Asia-Pacific	16	17	15	26.2	1	2.5	20.0	48.0	80
Europe	17	9	16	14.1	2	7.5	8.0	16.0	40
Latin America	6	13	6	33.5	6	20.0	20.0	46.3	80
North America	3	5	3	17.3	2	6.0	10.0	25.0	40
Global	**44**	**49**	**42**	**22.8**	**1**	**6.0**	**15.0**	**40.0**	**80**

TABLE 73. COMBINING RESPONSES TO QUESTION 1a TO GIVE NUMBER OF NDT COMPANIES THAT PROVIDE INITIAL RADIATION PROTECTION TRAINING, EITHER BY INTERNAL ARRANGEMENTS OR EXTERNALLY OR BOTH

	Initial theory training in RP			Initial practical training in RP			Total responses
	Within OR Outside Company	Within AND Outside Company	Neither	Within OR Outside Company	Within AND Outside Company	Neither	
Africa	6	0	1	5	0	2	7
Asia-Pacific	30	15	3	27	12	6	33
Europe	26	11	0	21	12	5	26
Latin America	19	7	0	16	5	3	19
North America	8	5	0	7	3	1	8
Global	**89**	**38**	**4**	**76**	**32**	**17**	**93**

TABLE 74. COMBINING RESPONSES TO QUESTION 1a TO GIVE TOTAL HOURS ON INITIAL TRAINING — THEORY

	Total duration of initial training, theory (hours)						
	Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Africa	6	24.5	8	12.5	22.0	36.0	45
Asia-Pacific	30	27.1	1	6.5	19.5	44.0	80
Europe	25	27.1	1	18.0	29.0	36.0	46
Latin America	19	67.3	4	47.5	65.0	80.0	160
North America	8	41.1	8	40.0	43.5	45.5	60
Global	**88**	**36.9**	**1**	**15.8**	**31.0**	**48.5**	**160**

TABLE 75. COMBINING RESPONSES TO QUESTION 1a TO GIVE TOTAL HOURS ON INITIAL TRAINING — PRACTICAL

	Total duration of initial training, practical (hours)						
	Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Africa	5	23.4	6	10	16	40	45
Asia-Pacific	27	25.7	1	4	16	29.5	104
Europe	21	24.1	2	8	16	32	100
Latin America	15	36.0	2	13.5	20	40	160
North America	7	56.4	1	7	10	35	300
Global	**75**	**30.0**	**1**	**8**	**16**	**40**	**300**

II.3.2. Refresher training

TABLE 76. RESPONSES TO QUESTION 1a(iii) — IF YES TO QUESTION 1, DO YOU PROVIDE, WITHIN THE COMPANY, REFRESHER RADIATION PROTECTION TRAINING (THEORY) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION AND AT WHAT INTERVAL?

	Yes	No	Duration of refresher training, theory, within the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	2	5	2	10.5	5	-	10.5	-	16
Asia-Pacific	18	15	17	8.5	1	4	8	8	24
Europe	17	9	17	4.6	1	1.5	3	4	30
Latin America	18	1	17	17.2	2	4	10	20	80
North America	6	2	6	3.7	1	2.3	3.5	4	8
Global	**61**	**32**	**59**	**9.5**	**1**	**3**	**4**	**9**	**80**
	Yes	**No**	**Interval between refresher training, theory, within the NDT company (months)**						
			Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Africa	2	5	2	30.0	12	-	30	-	48
Asia-Pacific	18	15	15	9.8	1	3	6	12	36
Europe	17	9	15	19.4	3	12	12	24	60
Latin America	18	1	14	8.6	6	6	6	12	12
North America	6	2	5	10.8	6	12	12	12	12
Global	**61**	**32**	**51**	**13.2**	**1**	**6**	**12**	**12**	**60**

TABLE 77. RESPONSES TO QUESTION 1a(iv) — IF YES TO QUESTION 1, DO YOU PROVIDE, WITHIN THE COMPANY, REFRESHER RADIATION PROTECTION TRAINING (PRACTICAL) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION AND AT WHAT INTERVAL?

	Yes	No	Duration of refresher training, practical, within the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	1	6	1	5.0	-	-	5	-	-
Asia-Pacific	14	19	13	7.8	1	2	8	8	24
Europe	12	14	11	5.2	1	2	2	3.5	30
Latin America	15	4	13	14.3	2	4	6	16	80
North America	4	4	3	2.3	1	-	1	-	5
Global	**46**	**47**	**41**	**8.7**	**1**	**2**	**4**	**8**	**80**
	Yes	**No**	**Interval between refresher training, practical, within the NDT company (months)**						
			Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Africa	1	6	1	12.0	-	-	12	-	-
Asia-Pacific	14	19	11	7.5	1	3	8	12	12
Europe	12	14	10	16.5	3	12	12	12	60
Latin America	15	4	10	9.0	6	6	9	12	12
North America	4	4	4	6.0	3	3	4.5	7.5	12
Global	**46**	**47**	**36**	**10.4**	**1**	**6**	**12**	**12**	**60**

TABLE 78. RESPONSES TO QUESTION 1a(vii) — IF YES TO QUESTION 1, DO YOU PROVIDE, OUTSIDE THE COMPANY, REFRESHER RADIATION PROTECTION TRAINING (THEORY) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION AND AT WHAT INTERVAL?

	Yes	No	Duration of refresher training, theory, outside the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	2	5	2	32.0	24	-	32	-	40
Asia-Pacific	22	11	21	13.7	1	8	16	16	24
Europe	18	9	17	9.2	2	6	8	10	21
Latin America	6	13	6	27.8	6	17	20	23.8	80
North America	0	8	0	-	-	-	-	-	-
Global	**48**	**46**	**46**	**14.7**	**1**	**8**	**15**	**19**	**80**

	Yes	No	Interval between refresher training, theory,outside the NDT company (months)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	2	5	1	60.0	-		60	-	-
Asia-Pacific	22	11	17	21.0	1	12	24	24	36
Europe	17	9	13	54.2	20	60	60	60	60
Latin America	6	13	6	21.0	6	15	24	24	36
North America	0	8	0	-	-	-	-	-	-
Global	**47**	**46**	**37**	**33.7**	**1**	**24**	**24**	**60**	**60**

TABLE 79. RESPONSES TO QUESTION 1a(viii) — IF YES TO QUESTION 1, DO YOU PROVIDE, OUTSIDE THE COMPANY, REFRESHER RADIATION PROTECTION TRAINING (PRACTICAL) TO YOUR RADIOGRAPHERS AND, IF SO, WHAT DURATION AND AT WHAT INTERVAL?

	Yes	No	Duration of refresher training, practical, outside the NDT company (hours)						
			Data	Mean	Min	Q1	Median	Q3	Max
Africa	1	6	1	24.0	-	-	24	-	-
Asia-Pacific	13	20	11	18.9	1	3	8	18	80
Europe	10	16	10	5.5	1	2	4	8	14
Latin America	5	14	5	26.4	6	6	20	20	80
North America	0	8	0	-	-	-	-	-	-
Global	**29**	**64**	**27**	**15.5**	**1**	**3**	**8**	**18**	**80**
	Yes	**No**	**Interval between refresher training, practical, outside the NDT company (months)**						
			Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Africa	1	6	1	60.0	-	-	60	-	-
Asia-Pacific	13	20	8	15.4	1	5	9	24	48
Europe	10	16	8	55.5	24	60	60	60	60
Latin America	5	14	5	20.4	6	12	24	24	36
North America	0	8	0	-	-	-	-	-	-
Global	**29**	**64**	**22**	**33.1**	**1**	**12**	**24**	**60**	**60**

TABLE 80. COMBINING RESPONSES TO QUESTION 1a TO GIVE NUMBER OF NDT COMPANIES THAT PROVIDE REFRESHER RADIATION PROTECTION TRAINING, EITHER BY INTERNAL ARRANGEMENTS OR EXTERNALLY OR BOTH

	Refresher theory training in RP			**Refresher practical training in RP**			**Total responses**
	Within OR Outside Company	Within AND Outside Company	Neither	Within OR Outside Company	Within AND Outside Company	Neither	
Africa	4	0	3	2	0	5	7
Asia-Pacific	26	14	7	18	9	15	33
Europe	23	12	3	15	7	11	26
Latin America	18	6	1	15	5	4	19
North America	6	0	2	4	0	4	8
Global	**77**	**32**	**16**	**54**	**21**	**39**	**93**

TABLE 81. COMBINING RESPONSES TO QUESTION 1a TO GIVE TOTAL HOURS ON REFRESHER RADIATION PROTECTION TRAINING PER 5 YEARS — THEORY

	Total duration of refresher training per 5 years, theory (hours)						
	Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Africa	3	23.0	-	-	-	-	-
Asia-Pacific	21	126.7	10	40	40	120	900
Europe	18	22.8	5	10	16	22	85
Latin America	15	170.1	20	43	80	217	800
North America	5	22.0	-	-	-	-	-
Global	**62**	**93.5**	**5**	**18**	**40**	**80**	**900**

TABLE 82. COMBINING RESPONSES TO QUESTION 1a TO GIVE TOTAL HOURS ON REFRESHER RADIATION PROTECTION TRAINING PER 5 YEARS — PRACTICAL

	Total duration of refresher training per 5 years, practical (hours)						
	Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Africa	2	24.5	-	-	-	-	-
Asia-Pacific	12	113.3	10	35	50	123	570
Europe	12	20.0	2	9	17	21	80
Latin America	10	170.3	20	40	60	205	800
North America	3	21.7	-	-	-	-	-
Global	**39**	**87.6**	**2**	**20**	**30**	**78**	**800**

II.3.3. Radiation protection training — gamma sources versus X ray sources

TABLE 83. RESPONSES TO QUESTION 1b — IF YES TO QUESTION 1, DO YOU PROVIDE DIFFERENT RADIATION PROTECTION TRAINING FOR GAMMA SOURCES AND FOR X RAY SOURCES?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	4	3	0	0	7
Asia-Pacific	20	13	0	0	33
Europe	10	16	0	0	26
Latin America	13	6	0	0	19
North America	2	5	0	1	8
Global	**49**	**43**	**0**	**1**	**93**

II.3.4. Radiation protection training — emergency preparedness and response

TABLE 84. RESPONSES TO QUESTION 1c(i) — IF YES TO QUESTION 1, DOES YOUR RADIATION PROTECTION TRAINING INCLUDE EMERGENCY PROCEDURES, AS PART OF EMERGENCY PREPAREDNESS AND RESPONSE?

	Yes	No	Don't know	No reply	Total
Africa	6	0	0	1	7
Asia-Pacific	33	0	0	0	33
Europe	24	2	0	0	26
Latin America	19	0	0	0	19
North America	8	0	0	0	8
Global	**90**	**2**	**0**	**1**	**93**

TABLE 85. RESPONSES TO QUESTION 1c(ii) — IF YES TO QUESTION 1, DOES YOUR RADIATION PROTECTION TRAINING INCLUDE PRACTICAL EXERCISES FOR CREATING A SAFE SITUATION, AS PART OF EMERGENCY PREPAREDNESS AND RESPONSE?

	Yes	No	Don't know	No reply	Total
Africa	4	2	0	1	7
Asia-Pacific	29	4	0	0	33
Europe	18	8	0	0	26
Latin America	18	1	0	0	19
North America	8	0	0	0	8
Global	**77**	**15**	**0**	**1**	**93**

TABLE 86. RESPONSES TO QUESTION 1c(iii) — IF YES TO QUESTION 1, DOES YOUR RADIATION PROTECTION TRAINING INCLUDE PRACTICAL EXERCISES FOR SOURCE RECOVERY, AS PART OF EMERGENCY PREPAREDNESS AND RESPONSE?

	Yes	No	Don't know	No reply	Total
Africa	3	3	0	1	7
Asia-Pacific	27	5	0	1	33
Europe	12	14	0	0	26
Latin America	14	5	0	0	19
North America	4	4	0	0	8
Global	**60**	**31**	**0**	**2**	**93**

II.3.5. Radiation protection training as part of NDT training

TABLE 87. RESPONSES BY NDT COMPANIES TO QUESTION 2 — IS RADIATION PROTECTION TRAINING INCLUDED AS PART OF NDT TRAINING IN RADIOGRAPHIC TESTING IN YOUR COUNTRY?

	Yes	No	Don't know	Total
	NDT Level 1			
Africa	5	0	2	7
Asia-Pacific	30	2	1	33
Europe	18	7	3	28
Latin America	15	3	1	19
North America	8	0	0	8
Global	**76**	**12**	**7**	**95**
	NDT Level 2			
Africa	4	1	2	7
Asia-Pacific	23	7	3	33
Europe	19	7	2	28
Latin America	12	6	1	19
North America	7	1	0	8
Global	**65**	**22**	**8**	**95**
	NDT Level 3			
Africa	2	3	2	7
Asia-Pacific	14	15	4	33
Europe	14	11	3	28
Latin America	7	9	3	19
North America	3	4	1	8
Global	**40**	**42**	**13**	**95**

TABLE 88. COMBINED RESPONSES PER COUNTRY TO QUESTION 2 — IS RADIATION PROTECTION TRAINING INCLUDED AS PART OF NDT TRAINING IN RADIOGRAPHIC TESTING IN YOUR COUNTRY?

	Yes	No	Don't know	Contradictory*	Total
	NDT Level 1				
Africa	3	0	1	0	4
Asia-Pacific	5	0	0	1	6
Europe	6	0	2	5	13
Latin America	3	0	0	1	4
North America	2	0	0	0	2
Global	**19**	**0**	**3**	**7**	**29**
	NDT Level 2				
Africa	2	1	1	0	4
Asia-Pacific	4	0	0	2	6
Europe	8	0	1	4	13
Latin America	2	0	0	2	4
North America	1	0	0	1	2
Global	**17**	**1**	**2**	**9**	**29**
	NDT Level 3				
Africa	0	2	1	1	4
Asia-Pacific	2	2	0	2	6
Europe	6	1	2	4	13
Latin America	1	1	0	2	4
North America	0	1	0	1	2
Global	**9**	**7**	**3**	**10**	**29**

* Contradictory means that some NDT companies answered 'yes', while others from the same country said 'no'.

TABLE 89. RESPONSES TO QUESTION 2a — IF YES TO ANY OF QUESTION 2, DOES YOUR COMPANY PROVIDE OR FACILITATE THE RADIATION PROTECTION TRAINING THAT YOU DETAILED IN QUESTIONS 1a, b, c, IN ADDITION TO THIS NDT RADIATION PROTECTION TRAINING?

	Yes	No	Don't know	No reply	Total
Africa	4	0	0	1	5
Asia-Pacific	30	1	0	1	32
Europe	14	3	2	1	20
Latin America	15	1	0	0	16
North America	7	1	0	0	8
Global	**70**	**6**	**2**	**3**	**81**

II.4. INCIDENTS — ACCIDENTS, NEAR MISSES AND DEVIATIONS FROM NORMAL

II.4.1. Number of incidents

TABLE 90. RESPONSES TO QUESTION 3 — HOW MANY RADIATION ACCIDENTS WITH INDIVIDUAL EXPOSURES HIGHER THAN THE ANNUAL LIMITS OCCURRED IN YOUR COMPANY DURING THE LAST FIVE YEARS?

	Number of accidents with individual exposures higher than the annual limits									No reply
	Replies	No. with 'no events'	Total no. of events	Mean	Min	Q1	Median	Q3	Max	
Africa	5	5	0	0.00	0	0	0	0	0	2
Asia-Pacific	29	26	6	0.21	0	0	0	0	4	4
Europe	27	24	5	0.19	0	0	0	0	3	1
Latin America	17	17	0	0.00	0	0	0	0	0	2
North America	8	8	0	0.00	0	0	0	0	0	0
Global	**86**	**80**	**11**	**0.13**	**0**	**0**	**0**	**0**	**4**	**9**

TABLE 91. RESPONSES TO QUESTION 3 — HOW MANY RADIATION ACCIDENTS WITH INDIVIDUAL EXPOSURES LOWER THAN THE ANNUAL LIMITS OCCURRED IN YOUR COMPANY DURING THE LAST FIVE YEARS?

	Number of accidents with elevated individual exposures lower than the annual limits									No reply
	Replies	No. with 'no events'	Total no. of events	Mean	Min	Q1	Median	Q3	Max	
Africa	5	5	0	0.00	0	0	0	0	0	2
Asia-Pacific	29	25	13	0.45	0	0	0	0	6	4
Europe	27	22	47	1.74	0	0	0	0	35	1
Latin America	17	13	9	0.53	0	0	0	0.3	4	2
North America	8	7	13	1.63	0	0	0	0	13	0
Global	**86**	**72**	**82**	**0.95**	**0**	**0**	**0**	**0**	**35**	**9**

TABLE 92. RESPONSES TO QUESTION 3 — HOW MANY NEAR MISSES WITH THE POTENTIAL FOR INDIVIDUAL EXPOSURES GREATER THAN THE ANNUAL LIMITS OCCURRED IN YOUR COMPANY DURING THE LAST FIVE YEARS?

	Number of near misses that had the potential for elevated individual exposures higher than the annual limits									No reply
	Replies	No. with 'no events'	Total no. of events	Mean	Min	Q1	Median	Q3	Max	
Africa	5	5	0	0.00	0	0	0	0	0	2
Asia-Pacific	27	25	3	0.11	0	0	0	0	2	6
Europe	27	23	19	0.69	0	0	0	0	10	1
Latin America	17	15	2	0.12	0	0	0	0	1	2
North America	8	6	36	4.50	0	0	0	0.5	34	0
Global	**84**	**74**	**60**	**0.71**	**0**	**0**	**0**	**0**	**34**	**11**

TABLE 93. RESPONSES TO QUESTION 3 — HOW MANY NEAR MISSES WITH THE POTENTIAL FOR INDIVIDUAL EXPOSURES LOWER THAN THE ANNUAL LIMITS OCCURRED IN YOUR COMPANY DURING THE LAST FIVE YEARS?

	Number of near misses that had the potential for elevated individual exposures lower than the annual limits									No reply
	Replies	No. with 'no events'	Total no. of events	Mean	Min	Q1	Median	Q3	Max	
Africa	5	4	1	0.20	0	0	0	0.0	1	2
Asia-Pacific	27	25	6	0.22	0	0	0	0	4	6
Europe	27	14	36	1.31	0	0	0	1.8	15	1
Latin America	18	13	9	0.50	0	0	0	1	2	1
North America	8	4	38	4.75	0	0	1	3.3	27	0
Global	**85**	**60**	**90**	**1.05**	**0**	**0**	**0**	**1**	**27**	**10**

TABLE 94. RESPONSES TO QUESTION 3 — HOW MANY DEVIATIONS FROM NORMAL OPERATIONS OCCURRED IN YOUR COMPANY DURING THE LAST FIVE YEARS?

	Number of other deviations from normal operations									No reply
	Replies	No. with 'no events'	Total no. of events	Mean	Min	Q1	Median	Q3	Max	
Africa	5	5	0	0.00	0	0	0.0	0.0	0	2
Asia-Pacific	26	25	36	1.38	0	0	0.0	0.0	36	7
Europe	22	17	69	3.14	0	0	0.0	0.0	52	6
Latin America	17	13	20	1.18	0	0	0.0	0.0	12	2
North America	8	4	15	1.88	0	0	0.5	1.5	10	0
Global	**78**	**64**	**140**	**1.79**	**0**	**0**	**0.0**	**0.0**	**52**	**17**

TABLE 95. COMBINED RESPONSES TO QUESTION 3, GIVING THE NUMBER OF NDT COMPANIES HAVING ZERO INCIDENTS, OR ONE OR MORE INCIDENTS

	Zero accidents, near misses or deviations	One or more events of any kind	No reply	Total
Africa	4	1	2	7
Asia-Pacific	24	5	4	33
Europe	11	16	1	28
Latin America	10	8	1	19
North America	3	5	0	8
Global	**52**	**35**	**8**	**95**

TABLE 96. FURTHER ANALYSIS OF RESPONSES TO QUESTION 3, GIVING DATA ON THE NUMBER OF NDT COMPANIES REPORTING THAT THEY HAD HAD NO RADIATION INCIDENTS IN THEIR COMPANY DURING THE LAST FIVE YEARS

	Zero accidents		Zero near misses		Zero deviations	
	Number of NDT companies	%	Number of NDT companies	%	Number of NDT companies	%
Africa	5	100	4	80	5	100
Asia-Pacific	25	86	24	89	25	96
Europe	22	81	14	52	17	77
Latin America	13	81	13	76	13	76
North America	7	88	4	50	4	50
Global	**72**	**85**	**59**	**70**	**64**	**82**

TABLE 97. FROM THE RESPONSES TO QUESTION 3, THE DERIVED NUMBER OF RADIATION INCIDENTS PER INDUSTRIAL RADIOGRAPHER DURING THE LAST FIVE YEARS

	Average number of events per industrial radiographer per 5 years:				
	Accidents with individual exposures higher than the annual limits	**Accidents with individual exposures lower than the annual limits**	**Near misses with the potential for elevated individual exposures higher than the annual limit**	**Near misses with the potential for elevated individual exposures lower than the annual limit**	**Other deviations from normal operations**
Africa	0.000	0.000	0.000	0.029	0.000
Asia-Pacific	0.008	0.019	0.005	0.009	0.056
Europe	0.004	0.039	0.015	0.029	0.057
Latin America	0.000	0.018	0.004	0.016	0.041
North America	0.000	0.021	0.057	0.061	0.024
Global	**0.003**	**0.027**	**0.020**	**0.030**	**0.047**

TABLE 98. ACCIDENTS, NEAR MISSES AND DEVIATIONS FROM NORMAL PER NDT COMPANY PER 5 YEARS, BASED ON THE RADIOGRAPHER RESPONSES TO QUESTION 8 OF THE RADIOGRAPHER QUESTIONNAIRE (SEE APPENDIX I), SCALED BY THE RATIO OF THE NUMBER OF RADIOGRAPHERS IN THE NDT COMPANY TO THE NUMBER OF RESPONDING RADIOGRAPHERS

	Number of NDT companies represented	**Average number of events per NDT company per 5 years**		
		Deviations from normal	**Near misses**	**Accidents**
Africa	4	0.0	2.3	0.0
Asia-Pacific	22	31.3	4.5	9.1
Europe	20	29.1	4.3	0.0
Latin America	13	6.7	6.0	1.4
North America	4	121.4	29.2	8.3
Global	**63**	**29.3**	**6.2**	**4.0**

Note: There were 63 NDT companies where data were known for: the number of industrial radiographers at the company, the company statistics on the number of events in the last 5 years, and at least one industrial radiographer from the company who had provided statistics on their number of events in the last 5 years. In most of these cases, there were zero events, but for the small number of cases where events had occurred (6 for deviations, 7 for near misses, and 4 for accidents) there was no agreement between the company statistics and the scaled radiographers' statistics. (The radiographer statistics were scaled by the total number of radiographers in the company divided by the number of radiographers that provided event statistics). This is perhaps not surprising given that the scaling factor ranged from 1 to over 100, with an average of 62, coupled with the small number of events for a given radiographer. Further analysis is given in Tables 99–101.

TABLE 99. COMPARISON OF ESTIMATES OF ACCIDENTS PER NDT COMPANY PER 5 YEARS

	Accidents per NDT company per 5 years							
	All NDT companies[a]		**NDT companies with radiographer numbers[b]**		**NDT companies with radiographer numbers and radiographers that also responded[c]**		**Scaled responses from radiographers at NDT companies[d]**	
	Data	**Mean**	**Data**	**Mean**	**Data**	**Mean**	**Data**	**Mean**
Africa	5	0.0	5	0.0	4	0.0	4	0.0
Asia-Pacific	29	0.7	22	0.8	22	0.8	22	9.1
Europe	27	1.9	27	1.9	20	2.4	20	0.0
Latin America	16	0.6	17	0.5	13	0.7	13	1.4
North America	8	1.6	8	1.6	4	3.3	4	8.3
Global	**85**	**1.1**	**79**	**1.2**	**63**	**1.4**	**63**	**4.0**

[a] Estimates are based on all the valid NDT company responses.

[b] Estimates are based on the NDT company responses that also gave the total number of radiographers.

[c] Estimates are based on the NDT company responses that also gave total number of radiographers and had at least one radiographer who responded to the radiographer questionnaire.

[d] Estimates are based on the radiographer responses to Question 8 of the Radiographer Questionnaire, scaled by the ratio of the number of radiographers in the NDT company to the number of responding radiographers.

TABLE 100. COMPARISON OF ESTIMATES OF NEAR MISSES PER NDT COMPANY PER 5 YEARS

	Near misses per NDT company per 5 years							
	All NDT companies[a]		NDT companies with radiographer numbers[b]		NDT companies with radiographer numbers and radiographers that also responded[c]		Scaled responses from radiographers at NDT companies[d]	
	Data	Mean	Data	Mean	Data	Mean	Data	Mean
Africa	5	0.2	5	0.2	4	0.3	4	2.3
Asia-Pacific	27	0.3	21	0.4	21	0.4	22	4.5
Europe	27	2.0	27	2.0	20	1.3	20	4.3
Latin America	17	0.7	17	0.6	13	0.6	13	6.0
North America	8	9.3	8	9.3	4	15.8	4	29.2
Global	**84**	**1.8**	**78**	**1.9**	**62**	**1.7**	**63**	**6.2**

[a] Estimates are based on all the valid NDT company responses.

[b] Estimates are based on the NDT company responses that also gave the total number of radiographers.

[c] Estimates are based on the NDT company responses that also gave total number of radiographers and had at least one radiographer who responded to the radiographer questionnaire.

[d] Estimates are based on the radiographer responses to Question 8 of the Radiographer Questionnaire, scaled by the ratio of the number of radiographers in the NDT company to the number of responding radiographers.

TABLE 101. COMPARISON OF ESTIMATES OF DEVIATIONS FROM NORMAL PER NDT COMPANY PER 5 YEARS

	Deviations from normal per NDT company per 5 years							
	All NDT companies[a]		NDT companies with radiographer numbers[b]		NDT companies with radiographer numbers and radiographers that also responded[c]		Scaled responses from radiographers at NDT companies[d]	
	Data	Mean	Data	Mean	Data	Mean	Data	Mean
Africa	5	0.0	5	0.0	4	0.0	4	0.0
Asia-Pacific	26	1.4	20	1.8	20	1.8	22	31.3
Europe	22	3.1	22	3.1	16	4.3	20	29.1
Latin America	17	1.2	17	1.2	13	1.5	13	6.7
North America	8	1.9	8	1.9	4	3.0	4	121.4
Global	**78**	**1.8**	**72**	**1.9**	**57**	**2.4**	**63**	**29.3**

[a] Estimates are based on all the valid NDT company responses.

[b] Estimates are based on the NDT company responses that also gave the total number of radiographers.

[c] Estimates are based on the NDT company responses that also gave total number of radiographers and had at least one radiographer who responded to the radiographer questionnaire.

[d] Estimates are based on the radiographer responses to Question 8 of the Radiographer Questionnaire, scaled by the ratio of the number of radiographers in the NDT company to the number of responding radiographers.

II.4.2. Reporting of incidents

TABLE 102. RESPONSES TO QUESTIONS 4a — HOW MANY RADIATION ACCIDENTS WITH INDIVIDUAL EXPOSURES HIGHER THAN THE ANNUAL LIMITS DID YOUR COMPANY REPORT TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Number of reported accidents with individual exposures higher than the annual limits								No reply
	Replies	Total	Mean	Min	Q1	Median	Q3	Max	
Africa	7	0	0.00	0	0	0	0	0	0
Asia-Pacific	27	6	0.22	0	0	0	0	4	6
Europe	25	5	0.20	0	0	0	0	3	3
Latin America	16	0	0.00	0	0	0	0	0	3
North America	8	0	0.00	0	0	0	0	0	0
Global	**83**	**11**	**0.13**	**0**	**0**	**0**	**0**	**4**	**12**

Note: The 11 reported accidents with individual exposures higher than the dose limits were from 6 NDT companies.

TABLE 103. RESPONSES TO QUESTIONS 4b — HOW MANY RADIATION ACCIDENTS WITH INDIVIDUAL EXPOSURES LOWER THAN THE ANNUAL LIMITS DID YOUR COMPANY REPORT TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Number of reported accidents with elevated individual exposures lower than the annual limits								No reply
	Replies	Total	Mean	Min	Q1	Median	Q3	Max	
Africa	7	0	0.00	0	0	0	0	0	0
Asia-Pacific	27	13	0.48	0	0	0	0	6	6
Europe	25	22	0.88	0	0	0	0	15	3
Latin America	16	9	0.56	0	0	0	0.25	4	3
North America	8	13	1.63	0	0	0	0	13	0
Global	**83**	**57**	**0.69**	**0**	**0**	**0**	**0**	**15**	**12**

Note: The 57 reported accidents with elevated individual exposures lower than the dose limits were from 13 NDT companies.

TABLE 104. RESPONSES TO QUESTIONS 4c — HOW MANY RADIATION NEAR MISSES THAT HAD THE POTENTIAL FOR INDIVIDUAL EXPOSURES HIGHER THAN THE ANNUAL LIMITS DID YOUR COMPANY REPORT TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Number of reported near misses that had the potential for elevated individual exposures higher than the annual limits								**No reply**
	Replies	**Total**	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**	
Africa	7	0	0.00	0	0	0	0	0	0
Asia-Pacific	25	3	0.12	0	0	0	0	2	8
Europe	25	3	0.12	0	0	0	0	2	3
Latin America	16	0	0.00	0	0	0	0	0	3
North America	8	10	1.25	0	0	0	0	10	0
Global	**81**	**16**	**0.20**	**0**	**0**	**0**	**0**	**10**	**14**

Note: The 16 reported near misses that had the potential for individual exposures higher than the dose limits were from 5 NDT companies.

TABLE 105. RESPONSES TO QUESTIONS 4d — HOW MANY RADIATION NEAR MISSES THAT HAD THE POTENTIAL FOR INDIVIDUAL EXPOSURES LOWER THAN THE ANNUAL LIMITS DID YOUR COMPANY REPORT TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Number of reported near misses that had the potential for elevated individual exposures lower than the annual limits								**No reply**
	Replies	**Total**	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**	
Africa	7	0	0.00	0	0	0	0	0	0
Asia-Pacific	25	2	0.08	0	0	0	0	2	8
Europe	25	9	0.36	0	0	0	0	2	3
Latin America	17	3	0.18	0	0	0	0	2	2
North America	8	6	0.75	0	0	0	0	6	0
Global	**82**	**20**	**0.24**	**0**	**0**	**0**	**0**	**6**	**13**

Note: The 20 reported near misses that had the potential for individual exposures lower than the dose limits were from 10 NDT companies.

TABLE 106. RESPONSES TO QUESTIONS 4e — HOW MANY OTHER DEVIATIONS FROM NORMAL OPERATIONS DID YOUR COMPANY REPORT TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Number of reported other deviations from normal operations								No reply
	Replies	**Total**	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**	
Africa	7	0	0.00	0	0	0	0	0	0
Asia-Pacific	24	2	0.08	0	0	0	0	2	9
Europe	23	12	0.52	0	0	0	0	10	5
Latin America	17	3	0.18	0	0	0	0	2	2
North America	8	4	0.50	0	0	0	1	2	0
Global	**79**	**21**	**0.27**	**0**	**0**	**0**	**0**	**10**	**16**

Note: The 21 reported other deviations from normal were from 9 NDT companies.

TABLE 107. RESPONSES TO QUESTION 5 — DID YOUR (RADIATION PROTECTION) REGULATORY BODY REPORT THE RADIATION INCIDENTS TO THE IAEA?

	Yes	**No**	**Don't know**	**Not applicable**	**Total**
Africa	0	0	0	7	7
Asia-Pacific	1	0	4	28	33
Europe	0	1	10	17	28
Latin America	0	0	7	12	19
North America	0	1	2	5	8
Global	**1**	**2**	**23**	**69**	**95**

Notes:

1. The responses to this question are dominated by 'don't know' and 'not applicable'. This is perhaps not surprising as the question asks about knowledge about another organization's activities and, further, most NDT companies had not reported incidents.

2. Notifications to the IAEA can be to two different parts of the Agency — those that report incidents which involved exposure which would be reported to the Incident and Emergency Centre (IEC); and those that involved loss of control of a source which would be reported to the illicit trafficking database. No independent collaboration was able to be made for individual responses.

3. The IEC had had 41 notifications of industrial radiography incidents involving exposure in the last 5 years.

II.4.3. Receiving information about incidents

Tables 108–112 summarize the responses to how the NDT companies receive information about abnormal individual exposures of its radiographers. In line with the questionnaire instructions, an option that was not selected was interpreted as being a 'no' response. 30 NDT companies indicated one method only; 34 used two methods; and 22 used three methods. Not surprisingly, the vast majority of approaches (85 out of 93) utilized combinations of radiographer and company active dosimetry, and passive dosimetry from the personal dosimetry provider. Two NDT companies gave no responses.

TABLE 108. RESPONSES TO QUESTION 6 — DOES YOUR COMPANY RECEIVE INFORMATION ABOUT ABNORMAL INDIVIDUAL EXPOSURES OF ITS RADIOGRAPHERS FROM: THE RADIOGRAPHERS?

	From the radiographers (e.g. based on the readout of their active dosimeters)?		
	Yes	**No**	**Total**
Africa	4	3	7
Asia-Pacific	15	17	32
Europe	19	8	27
Latin America	11	8	19
North America	6	2	8
Global	**55**	**38**	**93**

TABLE 109. RESPONSES TO QUESTION 6 — DOES YOUR COMPANY RECEIVE INFORMATION ABOUT ABNORMAL INDIVIDUAL EXPOSURES OF ITS RADIOGRAPHERS FROM: THE COMPANY'S OWN DOSIMETRY SYSTEM?

	From the NDT company's own personal dosimetry system (e.g. based on active dosimeters)?		
	Yes	**No**	**Total**
Africa	1	6	7
Asia-Pacific	11	21	32
Europe	4	23	27
Latin America	8	11	19
North America	3	5	8
Global	**27**	**66**	**93**

TABLE 110. RESPONSES TO QUESTION 6 — DOES YOUR COMPANY RECEIVE INFORMATION ABOUT ABNORMAL INDIVIDUAL EXPOSURES OF ITS RADIOGRAPHERS FROM: THE THIRD PARTY DOSIMETRY PROVIDER?

	From the third party personal dosimetry provider (e.g. based on the readout of passive dosimeters)?		
	Yes	**No**	**Total**
Africa	5	2	7
Asia-Pacific	19	13	32
Europe	22	5	27
Latin America	15	4	19
North America	7	1	8
Global	**68**	**25**	**93**

TABLE 111. RESPONSES TO QUESTION 6 — DOES YOUR COMPANY RECEIVE INFORMATION ABOUT ABNORMAL INDIVIDUAL EXPOSURES OF ITS RADIOGRAPHERS FROM: THE REGULATORY BODY?

	From the regulatory body (based on the readout of passive dosimeters)?		
	Yes	**No**	**Total**
Africa	1	6	7
Asia-Pacific	17	15	32
Europe	16	11	27
Latin America	5	14	19
North America	1	7	8
Global	**40**	**53**	**93**

TABLE 112. RESPONSES TO QUESTION 6 — DOES YOUR COMPANY RECEIVE INFORMATION ABOUT ABNORMAL INDIVIDUAL EXPOSURES OF ITS RADIOGRAPHERS FROM: ANOTHER SOURCE?

	From another source?		
	Yes	**No**	**Total**
Africa	0	7	7
Asia-Pacific	0	33	32
Europe	3	25	27
Latin America	2	17	19
North America	0	8	8
Global	**5**	**88**	**93**

Note: The 5 responses for ‘Another source’, were variations on company provisional dosimetry.

II.4.4. Disseminating information about incidents — within the company

Tables 113–118 summarize the responses to how the NDT companies share information about radiation incidents within their organizations. In line with the questionnaire instructions, an option that was not selected was interpreted as being a 'no' response.

There were 4 NDT companies with no responses to these questions, implying that they do not share information. 33 companies indicated one method only; 33 used two methods; and 15 used three methods. Almost all NDT companies used safety meetings and/or email (84 out of 91).

TABLE 113. RESPONSES TO QUESTION 7 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS, WITHIN YOUR ORGANIZATION, THROUGH: SAFETY MEETINGS?

	Safety meetings?		
	Yes	**No**	**Total**
Africa	5	0	5
Asia-Pacific	32	0	32
Europe	21	7	28
Latin America	16	2	18
North America	8	0	8
Global	**82**	**9**	**91**

TABLE 114. RESPONSES TO QUESTION 7 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS, WITHIN YOUR ORGANIZATION, THROUGH: NOTICE BOARDS?

	Notice boards?		
	Yes	**No**	**Total**
Africa	2	3	5
Asia-Pacific	14	18	32
Europe	6	22	28
Latin America	3	15	18
North America	4	4	8
Global	**29**	**62**	**91**

TABLE 115. RESPONSES TO QUESTION 7 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS, WITHIN YOUR ORGANIZATION, THROUGH: COMPANY MAGAZINE?

	Company magazine?		
	Yes	**No**	**Total**
Africa	1	4	5
Asia-Pacific	1	31	32
Europe	3	25	28
Latin America	0	18	18
North America	1	7	8
Global	**6**	**85**	**91**

TABLE 116. RESPONSES TO QUESTION 7 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS, WITHIN YOUR ORGANIZATION, THROUGH: COMPANY INTRANET?

	Company intranet?		
	Yes	**No**	**Total**
Africa	1	4	5
Asia-Pacific	6	26	32
Europe	4	24	28
Latin America	4	14	18
North America	1	7	8
Global	**16**	**75**	**91**

TABLE 117. RESPONSES TO QUESTION 7 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS, WITHIN YOUR ORGANIZATION, THROUGH: EMAIL?

	Email?		
	Yes	**No**	**Total**
Africa	2	3	5
Asia-Pacific	12	20	32
Europe	13	15	28
Latin America	7	11	18
North America	4	4	8
Global	2	3	5

TABLE 118. RESPONSES TO QUESTION 7 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS, WITHIN YOUR ORGANIZATION, THROUGH: OTHER MEANS?

	Other means?		
	Yes	**No**	**Total**
Africa	2	3	5
Asia-Pacific	3	29	32
Europe	6	22	28
Latin America	7	11	18
North America	2	6	8
Global	**20**	**71**	**91**

Note: 'Other means' included training, circulars and industry websites or bulletins.

II.4.5. Disseminating information about incidents — outside the company

Tables 119–123 summarize the responses to how the NDT companies share information about radiation incidents with other organizations. In line with the questionnaire instructions, an option that was not selected was interpreted as being a 'no' response.

There were 14 NDT companies that gave no responses to this question. 35 companies indicated one method only; 19 used two methods; and 4 used three methods.

TABLE 119. RESPONSES TO QUESTION 8 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS WITH OTHER ORGANIZATIONS THROUGH: AN INTERNATIONAL OR NATIONAL INCIDENT DATABASE?

	International or national incident database?		
	Yes	**No**	**Total**
Africa	2	5	7
Asia-Pacific	5	21	26
Europe	5	19	24
Latin America	0	16	16
North America	2	6	8
Global	**14**	**67**	**81**

TABLE 120. RESPONSES TO QUESTION 8 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS WITH OTHER ORGANIZATIONS THROUGH: INDUSTRY MEETINGS?

	Industry meetings?		
	Yes	**No**	**Total**
Africa	0	7	7
Asia-Pacific	15	11	26
Europe	6	18	24
Latin America	6	10	16
North America	4	4	8
Global	**31**	**50**	**81**

TABLE 121. RESPONSES TO QUESTION 8 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS WITH OTHER ORGANIZATIONS THROUGH: EMAIL?

	Email?		
	Yes	**No**	**Total**
Africa	1	6	7
Asia-Pacific	12	14	26
Europe	4	20	24
Latin America	8	8	16
North America	1	7	8
Global	**26**	**55**	**81**

TABLE 122. RESPONSES TO QUESTION 8 — DOES YOUR COMPANY SHARE INFORMATION ABOUT RADIATION INCIDENTS WITH OTHER ORGANIZATIONS THROUGH: OTHER MEANS?

	Other means?		
	Yes	**No**	**Total**
Africa	1	6	7
Asia-Pacific	5	21	26
Europe	4	20	24
Latin America	7	9	16
North America	1	7	8
Global	**18**	**63**	**81**

Note: The 18 ‘other means’ included through training courses, regulatory body, NDT or radiation protection societies, and accident reports.

TABLE 123. RESPONSES TO QUESTION 8 — DOES YOUR COMPANY NOT SHARE INFORMATION ABOUT RADIATION INCIDENTS WITH OTHER ORGANIZATIONS?

	The company does NOT share information?		
	Yes	**No**	**Total**
Africa	4	3	7
Asia-Pacific	2	24	26
Europe	10	14	24
Latin America	3	13	16
North America	3	5	8
Global	**22**	**59**	**81**

II.5. SYSTEMS AND PROCEDURES FOR SAFE OPERATION

II.5.1. Personal dosimeters

Tables 124–126 present data on the personal dosimeters provided by the NDT companies to their radiographers, and the dosimeters' features. All NDT companies stated that they supplied at least one form of dosimeter. 72 out of 95 stated that they supplied both passive and active dosimeters.

TABLE 124. RESPONSES TO QUESTION 9a — WITH REGARD TO INDIVIDUAL MONITORING, DOES YOUR COMPANY PROVIDE ITS RADIOGRAPHERS WITH PASSIVE INDIVIDUAL DOSIMETERS?

	Yes	**No**	**Total**
Africa	6	1	7
Asia-Pacific	28	5	33
Europe	25	3	28
Latin America	18	1	19
North America	7	1	8
Global	**84**	**11**	**95**

TABLE 125. RESPONSES TO QUESTION 9b — WITH REGARD TO INDIVIDUAL MONITORING, DOES YOUR COMPANY PROVIDE ITS RADIOGRAPHERS WITH ACTIVE INDIVIDUAL DOSIMETERS?

	Yes	**No**	**Total**
Africa	5	2	7
Asia-Pacific	29	4	33
Europe	25	3	28
Latin America	15	4	19
North America	8	0	8
Global	**82**	**13**	**95**

TABLE 126. RESPONSES TO QUESTION 9c — IF YES TO QUESTION 9b, WHAT FEATURES ARE THE ACTIVE INDIVIDUAL DOSIMETERS EQUIPPED WITH?

	Visual alarms?				
	All	**Some**	**No**	**No reply**	**Total**
Africa	2	1	2	0	5
Asia-Pacific	18	2	9	0	29
Europe	15	6	4	0	25
Latin America	3	6	6	0	15
North America	5	1	2	0	8
Global	**43**	**16**	**23**	**0**	**82**
	Audible alarms?				
	All	**Some**	**No**	**No reply**	**Total**
Africa	4	0	1	0	5
Asia-Pacific	22	5	2	0	29
Europe	25	0	0	0	25
Latin America	11	3	1	0	15
North America	8	0	0	0	8
Global	**70**	**8**	**4**	**0**	**82**
	Vibrating alarms?				
	All	**Some**	**No**	**No reply**	**Total**
Africa	0	0	5	0	5
Asia-Pacific	1	2	26	0	29
Europe	2	5	18	0	25
Latin America	1	0	14	0	15
North America	0	1	7	0	8
Global	**4**	**8**	**70**	**0**	**82**

II.5.2. Company records of occupational doses and investigation levels

TABLE 127. RESPONSES TO QUESTION 10 — DOES YOUR COMPANY KEEP RECORDS OF THE OCCUPATIONAL DOSES RECEIVED BY ITS RADIOGRAPHERS?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	0	7
Asia-Pacific	33	0	0	0	33
Europe	28	0	0	0	28
Latin America	19	0	0	0	19
North America	8	0	0	0	8
Global	**95**	**0**	**0**	**0**	**95**

TABLE 128. RESPONSES TO QUESTION 10a — IF YES TO QUESTION 10, DOES YOUR COMPANY INFORM ITS RADIOGRAPHERS OF THEIR PERSONAL DOSES?

	Yes	No	Don't know	No reply	Total
Africa	5	1	1	0	7
Asia-Pacific	31	0	0	2	33
Europe	27	1	0	0	28
Latin America	19	0	0	0	19
North America	8	0	0	0	8
Global	**90**	**2**	**1**	**2**	**95**

TABLE 129. RESPONSES TO QUESTION 10b — ARE THERE INVESTIGATION LEVELS FOR PERSONAL DOSES ESTABLISHED BY THE COMPANY OR THE REGULATORY BODY?

	The company?				
	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	5	1	1	0	7
Asia-Pacific	21	10	1	1	33
Europe	14	13	1	0	28
Latin America	10	9	0	0	19
North America	8	0	0	0	8
Global	**58**	**33**	**3**	**1**	**95**
	The regulatory body?				
	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	3	1	3	0	7
Asia-Pacific	22	4	1	6	33
Europe	22	3	2	1	28
Latin America	19	0	0	0	19
North America	6	0	2	0	8
Global	**72**	**8**	**8**	**7**	**95**

TABLE 130. RESPONSES TO QUESTION 10c — IF YES TO EITHER PART OF QUESTION 10b, HOW MANY INVESTIGATIONS HAVE BEEN PERFORMED BY THE COMPANY IN THE LAST 5 YEARS AS A RESULT OF THE INVESTIGATION LEVEL BEING EXCEEDED?

	Number of investigations by NDT companies in 5 years								**Number of investigations in 5 years per operator**	
	Replies	**Total**	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**	**Replies**	**Mean**
Africa	6	6	1.0	0	0	1	2	2	5	0.45
Asia-Pacific	25	82	3.3	0	0	1	4	27	18	0.04
Europe	23	320	13.9	0	0	0	10	200	22	0.18
Latin America	17	231	13.6	0	0	1	20	56	15	0.27
North America	8	114	14.3	0	0.75	2	4.25	100	8	0.24
Global	**79**	**753**	**9.5**	**0**	**0**	**1**	**5**	**200**	**68**	**0.19**

Note: 37 of the 79 replies stated that they had performed no investigations — namely, 3, 11, 13, 8 and 2 for the regions Africa, Asia-Pacific, Europe, Latin America and North America, respectively.

TABLE 131. RESPONSES TO QUESTION 10d — IF YES TO QUESTION 10, PLEASE PROVIDE THE NUMBER OF WORKERS WHOSE ANNUAL INDIVIDUAL EFFECTIVE DOSES IN 2009 WERE IN THE FOLLOWING DOSE RANGES:

	Number of workers with annual dose in 2009, D, in the dose bands:						
	Annual effective dose bands (mSv)						
	D<mdl	**mdl≤D<1**	**1≤D<5**	**5≤D<10**	**10≤D<20**	**20≤D<50**	**D≥50**
Africa	13	3	4	0	0	1	0
Asia-Pacific	236	258	274	50	20	4	1
Europe	306	431	473	116	10	1	0
Latin America	190	118	130	19	13	3	0
North America	102	301	223	57	18	0	0
Global	**847**	**1111**	**1104**	**242**	**61**	**9**	**1**

Note: mdl = minimum detection limit of the personal dosimetry system.

76 NDT companies provided dose data: 5, 21, 25, 18 and 7 from Africa, Asia-Pacific, Europe, Latin America and North America, respectively. Banded dose data were given for a total of 3375 industrial radiographers. One NDT company stated that 2 workers exceeded 50 mSv in 2009, but gave no data for the other workers in the company, and hence are not included in the table.

TABLE 132. USING THE DATA FROM TABLE 131, PERCENTAGES OF MONITORED INDUSTRIAL RADIOGRAPHERS WHOSE ANNUAL EFFECTIVE DOSEs (D) WERE IN THE GIVEN DOSE BANDS

	Percentage of workers with annual dose in 2009, D, in the dose bands:						
	Annual effective dose bands (mSv)						
	D<mdl	**mdl≤D<1**	**1≤D<5**	**5≤D<10**	**10≤D<20**	**20≤D<50**	**D≥50**
Africa	56.5	13.0	17.4	0.0	0.0	4.3	8.7
Asia-Pacific	28.0	30.6	32.5	5.9	2.4	0.4	0.1
Europe	22.9	32.2	35.4	8.7	0.8	0.1	0.0
Latin America	40.2	24.9	27.5	4.0	2.7	0.6	0.0
North America	14.6	42.9	31.8	8.1	2.6	0.0	0.0
Global	**25.1**	**32.9**	**32.7**	**7.2**	**1.9**	**0.1**	**0.1**

Note: mdl = minimum detection limit of the personal dosimetry system.

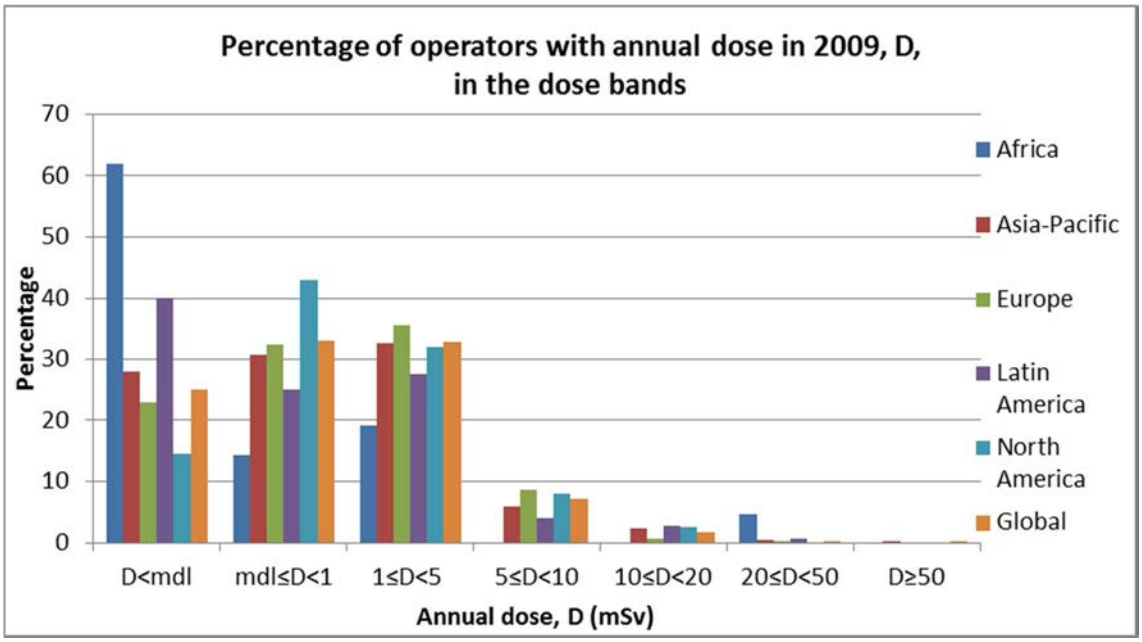

FIG. 26. Results from Table 132 giving percentages of industrial radiographers whose 2009 annual effective doses, D, were in the given dose bands, using the data from the NDT companies. Note, mdl = minimum detection limit of the personal dosimetry system.

II.5.3. Survey meters and area monitors

Tables 133–134 present data on the survey meters and area monitors provided by the NDT companies to their radiographers, and the equipment features. Two NDT companies also stated that they supplied personal bleepers to their radiographers.

TABLE 133. RESPONSES TO QUESTION 11a & b — DOES YOUR COMPANY PROVIDE ANY OTHER MONITORING OR ALARM DEVICES TO YOUR RADIOGRAPHERS?

	Survey meter?			
	Yes	**No**	**No reply**	**Total**
Africa	5	2	0	7
Asia-Pacific	30	2	1	33
Europe	24	4	0	28
Latin America	19	0	0	19
North America	8	0	0	8
Global	**86**	**8**	**1**	**95**
	Area monitor?			
	Yes	**No**	**No reply**	**Total**
Africa	4	3	0	7
Asia-Pacific	23	9	1	33
Europe	19	9	0	28
Latin America	15	4	0	19
North America	3	5	0	8
Global	**64**	**30**	**1**	**95**

TABLE 134. RESPONSES TO QUESTION 11c — IF YES TO QUESTION 11b, ARE THE AREA MONITORS EQUIPPED WITH VISUAL OR AUDIBLE ALARMS?

	Visual alarms?				
	All	**Some**	**No**	**No reply**	**Total**
Africa	2	2	0	0	4
Asia-Pacific	16	0	0	7	23
Europe	15	3	0	1	19
Latin America	10	2	2	1	15
North America	3	0	0	0	3
Global	**46**	**7**	**2**	**9**	**64**
	Audible alarms?				
	All	**Some**	**No**	**No reply**	**Total**
Africa	3	0	0	1	4
Asia-Pacific	16	3	1	3	23
Europe	15	3	1	0	19
Latin America	12	2	1	0	15
North America	3	0	0	0	3
Global	**49**	**8**	**3**	**4**	**64**

II.5.4. Radiation safety for the public — control of access and warnings

TABLE 135. RESPONSES TO QUESTION 12a — WITH REGARD TO A WARNING SYSTEM TO PREVENT ENTRY TO THE RADIOGRAPHY SITE: AT WHAT DOSE RATE DOES YOUR COMPANY REQUIRE A WARNING SYSTEM TO BE INSTALLED?

	Boundary dose rate (μSv/hr)							No reply
	Replies	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**	
Africa	3	5.8	2.5	5	7.5	7.5	7.5	4
Asia-Pacific	29	5.7	0.3	2.5	2.5	7.5	25	4
Europe	20	15.1	0	0.5	4.3	25	60	8
Latin America	12	20.5	0.5	6.1	20	21.3	60	7
North America	6	32.1	2.5	20	22.5	25	100	2
Global	**70**	**13.2**	**0**	**2.5**	**7.5**	**20**	**100**	**25**

TABLE 136. RESPONSES TO QUESTION 12b — WHAT IS USED AS A WARNING SYSTEM FOR THE WORK SITE?

	Ribbon or rope?			
	Yes	**No**	**No reply**	**Total**
Africa	3	3	1	7
Asia-Pacific	31	2	0	33
Europe	27	1	0	28
Latin America	15	4	0	19
North America	8	0	0	8
Global	**84**	**10**	**1**	**95**
	Passive warning signs?			
	Yes	**No**	**No reply**	**Total**
Africa	5	1	1	7
Asia-Pacific	24	9	0	33
Europe	22	6	0	28
Latin America	15	4	0	19
North America	5	3	0	8
Global	**71**	**23**	**1**	**95**
	Active warning signs?			
	Yes	**No**	**No reply**	**Total**
Africa	6	0	1	7
Asia-Pacific	26	7	0	33
Europe	17	11	0	28
Latin America	15	4	0	19
North America	3	5	0	8
Global	**67**	**27**	**1**	**95**

Note: Two NDT companies responded that they used ‘watchmen’ as a means for preventing entry into the work site.

TABLE 137. RESPONSES TO QUESTION 13 — HAS YOUR COMPANY DETERMINED THE MORE COMMON CAUSES FOR UNAUTHORIZED PERSONS TO TRESPASS PAST THE WARNING SYSTEM?

	Yes	No	Don't know	No reply	Total
Africa	2	2	3	0	7
Asia-Pacific	18	13	1	1	33
Europe	16	7	3	2	28
Latin America	11	6	1	1	19
North America	6	1	1	0	8
Global	**53**	**29**	**9**	**4**	**95**

TABLE 138. RESPONSES TO QUESTION 13a — IF YES TO QUESTION 13, WHAT ARE THE MORE COMMON CAUSES?

	Warning system is not understood?			
	Yes	**No**	**No reply**	**Total**
Africa	0	2	0	2
Asia-Pacific	13	3	2	18
Europe	10	6	0	16
Latin America	4	6	1	11
North America	3	3	0	6
Global	**30**	**20**	**3**	**53**
	Wilful violation?			
	Yes	**No**	**No reply**	**Total**
Africa	2	0	0	2
Asia-Pacific	11	5	2	18
Europe	15	1	0	16
Latin America	8	2	1	11
North America	6	0	0	6
Global	**42**	**8**	**3**	**53**
	Warning system was not set up properly to control the area?			
	Yes	**No**	**No reply**	**Total**
Africa	0	2	0	2
Asia-Pacific	4	12	2	18
Europe	3	13	0	16
Latin America	1	9	1	11
North America	2	4	0	6
Global	**10**	**40**	**3**	**53**

Note: Two NDT companies responded that inattention or distractions led to trespass, and three others stated that there was a lack of understanding about the actual dangers involved.

TABLE 139. RESPONSES TO QUESTION 14 — DOES YOUR COMPANY REQUIRE ITS RADIOGRAPHERS TO ANNOUNCE OR WARN WHENEVER A RADIOGRAPHIC EXPOSURE IS MADE?

	Always	Sometimes	No	Don't know	No reply	Total
Africa	4	2	0	1	0	7
Asia-Pacific	31	2	0	0	0	33
Europe	15	4	8	0	1	28
Latin America	14	3	2	0	0	19
North America	3	2	2	0	1	8
Global	**67**	**13**	**12**	**1**	**2**	**95**

TABLE 140. RESPONSES TO QUESTION 14a — IF YES (EITHER EVERY TIME OR SOMETIMES) TO QUESTION 14, IS THIS WITH?

	An audible alarm (e.g. siren, whistle)?			
	Yes	**No**	**No reply**	**Total**
Africa	1	3	2	6
Asia-Pacific	17	15	1	33
Europe	7	9	3	19
Latin America	6	7	4	17
North America	0	5	0	5
Global	**31**	**39**	**10**	**80**
	A visible alarm (e.g. flashing lights)?			
	Yes	**No**	**No reply**	**Total**
Africa	4	0	2	6
Asia-Pacific	30	2	1	33
Europe	14	2	3	19
Latin America	11	2	4	17
North America	1	4	0	5
Global	**60**	**10**	**10**	**80**
	An announcement via a public address system?			
	Yes	**No**	**No reply**	**Total**
Africa	1	3	2	6
Asia-Pacific	19	13	1	33
Europe	5	11	3	19
Latin America	7	7	3	17
North America	4	1	0	5
Global	**36**	**35**	**9**	**80**

8 NDT companies also responded that they used some form of direct communication with client personnel, such as phone, walky-talky or talking, and of these, 5 used this method only. Three NDT companies used specific warning signage in addition to other methods.

TABLE 141. FURTHER ANALYSIS OF RESPONSES TO QUESTION 14A ON MEANS USED TO ANNOUNCE OR WARN WHENEVER A RADIOGRAPHIC EXPOSURE IS MADE

	Audible alarm only	Visible alarm only	Announce -ment only	Other means only	Audible & visible alarms	Audible alarm & announce-ment	Visible alarm & announce -ment	Audible & visible alarms & announce -ment
Africa	0	3	0	0	0	0	0	1
Asia-Pacific	1	8	1	0	4	0	6	12
Europe	0	6	1	3	4	0	1	3
Latin America	0	3	3	2	4	0	2	2
North America	0	1	4	0	0	0	0	0
Global	**1**	**21**	**9**	**5**	**12**	**0**	**9**	**18**

Note: Five NDT companies answered yes to Question 14, but did not give any information on what methods they used.

II.5.5. Radiation safety for the public — clients' actions

Tables 142–148 present data on the actions taken by the client receiving the services being provided by the NDT company.

TABLE 142. RESPONSES TO QUESTION 15a — WHEN YOUR COMPANY IS PROVIDING RADIOGRAPHY SERVICES ON-SITE, DOES THE CLIENT PROVIDE YOUR COMPANY WITH A PLAN OF THE INSTALLATION?

	Provide your company with a plan of the installation?					
	Always	**Sometimes**	**Never**	**No reply**	**Not applicable**	**Total**
Africa	5	1	1	0	0	7
Asia-Pacific	25	7	1	0	0	33
Europe	5	18	2	1	2	28
Latin America	2	9	3	0	5	19
North America	0	5	2	1	0	8
Global	**37**	**40**	**9**	**2**	**7**	**95**

TABLE 143. RESPONSES TO QUESTION 15b — WHEN YOUR COMPANY IS PROVIDING RADIOGRAPHY SERVICES ON-SITE, DOES THE CLIENT INFORM YOUR COMPANY ABOUT INTERFERING ACTIVITIES ON-SITE?

	Inform your company about interfering activities on site?					
	Always	**Sometimes**	**Never**	**No reply**	**Not applicable**	**Total**
Africa	7	0	0	0	0	7
Asia-Pacific	27	5	1	0	0	33
Europe	11	12	2	1	2	28
Latin America	12	1	1	0	5	19
North America	3	4	0	1	0	8
Global	**60**	**22**	**4**	**2**	**7**	**95**

TABLE 144. RESPONSES TO QUESTION 15c — WHEN YOUR COMPANY IS PROVIDING RADIOGRAPHY SERVICES ON-SITE, DOES THE CLIENT HAVE A 'PERMIT TO WORK' SYSTEM?

	Have a 'permit to work' system?					
	Always	**Sometimes**	**Never**	**No reply**	**Not applicable**	**Total**
Africa	5	2	0	0	0	7
Asia-Pacific	26	5	1	1	0	33
Europe	5	19	1	1	2	28
Latin America	8	6	0	0	5	19
North America	1	6	0	1	0	8
Global	**45**	**38**	**2**	**3**	**7**	**95**

TABLE 145. RESPONSES TO QUESTION 15d(i) — WHEN YOUR COMPANY IS PROVIDING RADIOGRAPHY SERVICES ON-SITE, DOES THE CLIENT INFORM OTHER WORKERS ABOUT THE RADIOGRAPHY TO BE PERFORMED?

	Inform other workers about the radiography to be performed?					
	Always	**Sometimes**	**Never**	**No reply**	**Not applicable**	**Total**
Africa	6	1	0	0	0	7
Asia-Pacific	32	1	0	0	0	33
Europe	8	17	0	1	2	28
Latin America	11	3	0	0	5	19
North America	2	5	0	1	0	8
Global	**59**	**27**	**0**	**2**	**7**	**95**

TABLE 146. RESPONSES TO QUESTION 15d(ii) — WHEN YOUR COMPANY IS PROVIDING RADIOGRAPHY SERVICES ON-SITE, DOES THE CLIENT INFORM OTHER WORKERS ABOUT THE PURPOSE AND METHOD OF THE WARNING SYSTEM?

	Inform other workers about the purpose and method of the warning system (beaconing)?					
	Always	**Sometimes**	**Never**	**No reply**	**Not applicable**	**Total**
Africa	3	3	1	0	0	7
Asia-Pacific	29	2	2	0	0	33
Europe	3	20	2	1	2	28
Latin America	8	6	0	0	5	19
North America	2	2	3	1	0	8
Global	**45**	**33**	**8**	**2**	**7**	**95**

TABLE 147. RESPONSES TO QUESTION 15d(iii) — WHEN YOUR COMPANY IS PROVIDING RADIOGRAPHY SERVICES ON-SITE, DOES THE CLIENT INFORM OTHER WORKERS ABOUT THE MEANING OF ALARM SIGNALS?

	Inform other workers about the meaning of alarm signals?					
	Always	**Sometimes**	**Never**	**No reply**	**Not applicable**	**Total**
Africa	2	4	1	0	0	7
Asia-Pacific	30	2	1	0	0	33
Europe	4	18	3	1	2	28
Latin America	8	6	0	0	5	19
North America	2	4	1	1	0	8
Global	**46**	**34**	**6**	**2**	**7**	**95**

TABLE 148. RESPONSES TO QUESTION 15d(iv) — WHEN YOUR COMPANY IS PROVIDING RADIOGRAPHY SERVICES ON-SITE, DOES THE CLIENT INFORM OTHER WORKERS ABOUT THE RISKS OF IONIZING RADIATION/SOURCES?

	Inform other workers about the risks of ionizing radiation/sources?					
	Always	**Sometimes**	**Never**	**No reply**	**Not applicable**	**Total**
Africa	2	4	1	0	0	7
Asia-Pacific	31	1	1	0	0	33
Europe	3	20	2	1	2	28
Latin America	7	5	2	0	5	19
North America	2	3	2	1	0	8
Global	**45**	**33**	**8**	**2**	**7**	**95**

II.5.6. Use of collimators and diaphragms

Tables 149–150 present data on the use of collimators and diaphragms during radiography. The 'not applicable' responses were for NDT companies that were X ray radiography only, and gamma radiography only, respectively. There were 70 NDT companies that answered Question 16 for gamma radiography and for which there were at least one individual radiographer response for the same question in the radiographer survey (question 11). For the 68 NDT companies stating that they required collimation for gamma radiography, there were no companies for which the corresponding radiography responses stated that they never used collimation. About 80% of the radiographers said they always used collimation and about 20% said they sometimes used collimation. There were two instances where the NDT company did not require collimation, and one radiographer also said that they did not use collimation, while another replied that collimation was sometimes used.

For X ray radiography, there were 64 NDT companies that answered that part of Question 16 and for which there were at least one individual radiographer response for the same question in the radiographer survey (question 12). For the 45 NDT companies stating that they required collimation for X ray radiography, there were 8 companies where at least one of their corresponding radiographer responses said that they never used collimation. Conversely, there were 9 companies that did not require collimation, but for 5 of them the radiographers responded that they sometimes used collimation.

TABLE 149. RESPONSES TO QUESTION 16a — DOES YOUR COMPANY REQUIRE ITS RADIOGRAPHERS TO USE COLLIMATORS WITH GAMMA RADIOGRAPHY?

	Collimators with gamma radiography?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	4	2	0	1	7
Asia-Pacific	29	3	0	1	33
Europe	24	0	2	2	28
Latin America	15	0	0	4	19
North America	6	1	1	0	8
Global	**78**	**6**	**3**	**8**	**95**

TABLE 150. RESPONSES TO QUESTION 16b — DOES YOUR COMPANY REQUIRE ITS RADIOGRAPHERS TO USE DIAPHRAGMS OR COLLIMATORS WITH X RAY RADIOGRAPHY?

	Diaphragms or collimators with X ray radiography?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	3	0	2	7
Asia-Pacific	25	5	0	3	33
Europe	22	4	0	2	28
Latin America	12	1	2	4	19
North America	0	5	0	3	8
Global	**61**	**18**	**3**	**14**	**95**

II.5.7. Preventive maintenance — gamma devices

TABLE 151. RESPONSES TO QUESTION 17a — WITH REGARD TO EXPOSURE DEVICES FOR GAMMA RADIOGRAPHY, WHAT INTERVAL DOES YOUR COMPANY HAVE BETWEEN PREVENTIVE MAINTENANCE (MONTHS)?

	Interval between preventive maintenance (months)							Not applicable	No reply
	Data	Mean	Min	Q1	Median	Q3	Max		
Africa	3	10.0	3	7.5	12	13.5	15	1	1
Asia-Pacific	30	5.8	1	3	3	12	12	1	2
Europe	25	11.3	3	12	12	12	24	2	1
Latin America	13	6.2	3	6	6	6	12	4	2
North America	7	4.4	3	3	4	6	6	0	1
Global	**78**	**7.7**	**1**	**3**	**6**	**12**	**24**	**8**	**7**

Note: Two NDT companies stated that preventive maintenance was not performed. The 'not applicable' responses were for NDT companies performing X ray radiography only.

TABLE 152. RESPONSES TO QUESTION 17b(i) — IS THE CRANK INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Crank included?				
	Yes	No	No reply	Not applicable	Total
Africa	3	0	3	1	7
Asia-Pacific	28	4	0	1	33
Europe	25	0	1	2	28
Latin America	14	0	1	4	19
North America	7	0	1	0	8
Global	**77**	**4**	**6**	**8**	**95**

TABLE 153. RESPONSES TO QUESTION 17b(ii) — IS THE CONTROL CABLE INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Control cable included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	3	0	3	1	7
Asia-Pacific	32	0	0	1	33
Europe	25	0	1	2	28
Latin America	14	0	1	4	19
North America	7	0	1	0	8
Global	**81**	**0**	**6**	**8**	**95**

TABLE 154. RESPONSES TO QUESTION 17b(iii) — IS THE GUIDE TUBE INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Guide tube included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	3	0	3	1	7
Asia-Pacific	32	0	0	1	33
Europe	25	0	1	2	28
Latin America	14	0	1	4	19
North America	7	0	1	0	8
Global	**81**	**0**	**6**	**8**	**95**

TABLE 155. RESPONSES TO QUESTION 17b(iv) — IS THE COLLIMATOR INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Collimator included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	1	3	1	7
Asia-Pacific	25	7	0	1	33
Europe	19	6	1	2	28
Latin America	7	7	1	4	19
North America	3	4	1	0	8
Global	**56**	**25**	**6**	**8**	**95**

In addition to the items in Tables 152–155, 12 NDT companies specified other items included in their preventive maintenance, including various aspects of general equipment condition.

TABLE 156. RESPONSES TO QUESTION 17c — WHO PERFORMS THE PREVENTIVE MAINTENANCE?

	The NDT company?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	1	3	2	1	7
Asia-Pacific	26	6	0	1	33
Europe	12	13	1	2	28
Latin America	13	1	1	4	19
North America	8	0	0	0	8
Global	**60**	**23**	**4**	**8**	**95**
	The device manufacturer?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	3	1	2	1	7
Asia-Pacific	14	18	0	1	33
Europe	15	10	1	2	28
Latin America	0	14	1	4	19
North America	2	6	0	0	8
Global	**34**	**49**	**4**	**8**	**95**
	Other service company?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	1	3	2	1	7
Asia-Pacific	17	15	0	1	33
Europe	13	12	1	2	28
Latin America	7	7	1	4	19
North America	3	5	0	0	8
Global	**41**	**42**	**4**	**8**	**95**

TABLE 157. FURTHER ANALYSIS OF RESPONSES TO QUESTION 17c — WHO PERFORMS THE PREVENTIVE MAINTENANCE?

	NDT company only	Manufacturer only	Service company only	NDT company & manufacturer
Africa	1	2	0	0
Asia-Pacific	8	0	4	7
Europe	1	7	4	4
Latin America	7	0	1	0
North America	4	0	0	1
Global	**21**	**9**	**9**	**12**

	Manufacturer & service company	NDT company & service company	All three	No one* specified
Africa	1	0	0	2
Asia-Pacific	2	6	5	0
Europe	2	5	2	1
Latin America	0	6	0	1
North America	0	2	1	0
Global	**5**	**19**	**8**	**4**

***** Excluding 'not applicable' responses.
There were 83 NDT companies that provided at least one 'yes' response.

II.5.8. Preventive maintenance — X ray equipment

TABLE 158. RESPONSES TO QUESTION 18a — WITH REGARD TO EXPOSURE DEVICES FOR X RAY RADIOGRAPHY, WHAT INTERVAL DOES YOUR COMPANY HAVE BETWEEN PREVENTIVE MAINTENANCE (MONTHS)?

	Interval between preventive maintenance (months)							Not applicable	No reply
	Data	Mean	Min	Q1	Median	Q3	Max		
Africa	2	4.5	3	3.75	4.5	5.25	6	2	2
Asia-Pacific	26	6.4	1	3	5	12	12	4	3
Europe	23	10.5	1	12	12	12	12	3	2
Latin America	13	7.0	1	6	6	12	12	2	4
North America	3	6.0	0	3	6	9	12	2	3
Global	**67**	**7.9**	**0**	**3**	**6**	**12**	**12**	**13**	**14**

Note: One NDT company stated that preventative maintenance was not performed. The 'not applicable' responses were for NDT companies performing gamma radiography only.

TABLE 159. RESPONSES TO QUESTION 18b(i) — ARE THE CABLES INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Cables included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	0	3	2	7
Asia-Pacific	22	7	1	3	33
Europe	23	1	2	2	28
Latin America	15	0	0	4	19
North America	3	1	1	3	8
Global	**65**	**9**	**7**	**14**	**95**

TABLE 160. RESPONSES TO QUESTION 18b(ii) — IS THE CONTROL PANEL INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Control panel included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	0	3	2	7
Asia-Pacific	29	0	1	3	33
Europe	24	0	2	2	28
Latin America	14	1	0	4	19
North America	3	1	1	3	8
Global	**72**	**2**	**7**	**14**	**95**

TABLE 161. RESPONSES TO QUESTION 18b(iii) — IS THE DIAPHRAGM OR COLLIMATOR INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Diaphragm or collimator included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	0	3	2	7
Asia-Pacific	22	7	1	3	33
Europe	19	5	2	2	28
Latin America	10	5	0	4	19
North America	0	4	1	3	8
Global	**53**	**21**	**7**	**14**	**95**

TABLE 162. RESPONSES TO QUESTION 18b(iv) — IS THE OUTPUT OF THE TUBE (DOSE RATE) INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Output of tube (dose rate) included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	0	3	2	7
Asia-Pacific	25	3	2	3	33
Europe	19	5	2	2	28
Latin America	10	5	0	4	19
North America	1	3	1	3	8
Global	**57**	**16**	**8**	**14**	**95**

TABLE 163. RESPONSES TO QUESTION 18b(v) — IS LEAKAGE RADIATION INCLUDED IN THE PREVENTIVE MAINTENANCE?

	Leakage radiation included?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	0	3	2	7
Asia-Pacific	24	4	2	3	33
Europe	18	6	2	2	28
Latin America	11	4	0	4	19
North America	2	2	1	3	8
Global	**57**	**16**	**8**	**14**	**95**

In addition to the items in Tables 159–163, 6 NDT companies specified other items included in their preventive maintenance, including various aspects of general equipment condition.

TABLE 164. RESPONSES TO QUESTION 18c — WHO PERFORMS THE PREVENTIVE MAINTENANCE?

	The NDT company?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	0	3	2	2	7
Asia-Pacific	21	8	1	3	33
Europe	15	9	2	2	28
Latin America	11	4	0	4	19
North America	3	1	1	3	8
Global	**50**	**25**	**6**	**14**	**95**
	The device manufacturer?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	1	2	2	2	7
Asia-Pacific	11	18	1	3	33
Europe	11	13	2	2	28
Latin America	1	14	0	4	19
North America	0	4	1	3	8
Global	**24**	**51**	**6**	**14**	**95**
	Other service company?				
	Yes	**No**	**No reply**	**Not applicable**	**Total**
Africa	2	1	2	2	7
Asia-Pacific	19	9	2	3	33
Europe	13	11	2	2	28
Latin America	7	8	0	4	19
North America	0	4	1	3	8
Global	**41**	**33**	**7**	**14**	**95**

TABLE 165. FURTHER ANALYSIS OF RESPONSES TO QUESTION 18c — WHO PERFORMS THE PREVENTIVE MAINTENANCE

	NDT company only	Manufacturer only	Service company only	NDT company & manufacturer
Africa	0	1	2	0
Asia-Pacific	7	1	5	2
Europe	4	3	5	4
Latin America	7	0	4	1
North America	3	0	0	0
Global	**21**	**5**	**16**	**7**

	Manufacturer & service company	NDT company & service company	All three	No one* specified
Africa	0	0	0	2
Asia-Pacific	2	6	6	1
Europe	1	4	3	2
Latin America	0	3	0	0
North America	0	0	0	2
Global	**3**	**13**	**9**	**7**

***** Excluding 'not applicable' responses.

II.5.9. Radiation protection programme

TABLE 166. RESPONSES TO QUESTION 19a — DID THE MANAGING DIRECTOR OR CHIEF EXECUTIVE OFFICER APPROVE YOUR COMPANY'S RADIATION PROTECTION PROGRAMME?

	The managing director or chief executive officer?			
	Yes	No	No reply	Total
Africa	6	1	0	7
Asia-Pacific	21	12	0	33
Europe	18	10	0	28
Latin America	14	5	0	19
North America	4	4	0	8
Global	**63**	**32**	**0**	**95**

TABLE 167. RESPONSES TO QUESTION 19b — DID THE RADIATION PROTECTION OFFICER APPROVE YOUR COMPANY'S RADIATION PROTECTION PROGRAMME?

	The radiation protection officer?			
	Yes	**No**	**No reply**	**Total**
Africa	3	4	0	7
Asia-Pacific	18	15	0	33
Europe	19	9	0	28
Latin America	12	7	0	19
North America	7	1	0	8
Global	**59**	**36**	**0**	**95**

TABLE 168. RESPONSES TO QUESTION 19c — DID THE RADIATION PROTECTION REGULATORY BODY APPROVE YOUR COMPANY'S RADIATION PROTECTION PROGRAMME?

	The radiation protection regulatory body?			
	Yes	**No**	**No reply**	**Total**
Africa	2	5	0	7
Asia-Pacific	16	16	1	33
Europe	17	11	0	28
Latin America	15	3	1	19
North America	7	1	0	8
Global	**57**	**36**	**2**	**95**

TABLE 169. FURTHER ANALYSIS OF RESPONSES TO QUESTION 19 — WHO APPROVED YOUR COMPANY'S RADIATION PROTECTION PROGRAMME?

	MD/CEO only	RPO only	RB only	MD/CEO & RPO
Africa	2	0	1	3
Asia-Pacific	10	4	4	3
Europe	3	4	4	4
Latin America	2	2	2	0
North America	0	1	1	0
Global	**17**	**11**	**12**	**10**

	RPO & RB	MD/CEO & RB	All three	No one specified
Africa	0	1	0	0
Asia-Pacific	4	1	7	0
Europe	2	2	9	0
Latin America	1	3	9	0
North America	2	0	4	0
Global	**9**	**7**	**29**	**0**

Note: MD = managing director; CEO = chief executive officer; RB = regulatory body; RPO = radiation protection officer.

II.5.10. Company inspections

TABLE 170. RESPONSES TO QUESTION 20 — DOES YOUR COMPANY PERFORM ITS OWN COMPLIANCE INSPECTIONS OF ITS RADIOGRAPHERS?

	Yes	No	Don't know	No reply	Total
Africa	5	1	1	0	7
Asia-Pacific	32	0	0	1	33
Europe	27	1	0	0	28
Latin America	17	1	0	1	19
North America	8	0	0	0	8
Global	**89**	**3**	**1**	**2**	**95**

TABLE 171. RESPONSES TO QUESTION 20a — IF YES TO QUESTION 20, ARE THERE PLANNED COMPLIANCE INSPECTIONS?

	Yes	No	Don't know	No reply	Total
Africa	3	2	0	0	5
Asia-Pacific	28	2	0	2	32
Europe	10	16	1	0	27
Latin America	6	11	0	0	17
North America	6	2	0	0	8
Global	**53**	**33**	**1**	**2**	**89**

TABLE 172. RESPONSES TO QUESTION 20b — IF YES TO QUESTION 20, ARE THERE UNPLANNED COMPLIANCE INSPECTIONS?

	Yes	No	Don't know	No reply	Total
Africa	3	2	0	0	5
Asia-Pacific	21	7	2	2	32
Europe	23	3	1	0	27
Latin America	13	4	0	0	17
North America	7	1	0	0	8
Global	**67**	**17**	**3**	**2**	**89**

TABLE 173. FURTHER ANALYSIS OF RESPONSES TO QUESTION 20a & b — ARE THERE PLANNED AND UNPLANNED INSPECTIONS?

	Planned only	Unplanned only	Both	No inspections	Total
Africa	1	1	2	1	5
Asia-Pacific	9	2	19	0	30
Europe	2	15	8	1	26
Latin America	4	11	2	0	17
North America	1	2	5	0	8
Global	**17**	**31**	**36**	**2**	**86**

TABLE 174. RESPONSES TO QUESTION 20c — IF YES TO QUESTION 20, BY WHOM ARE THESE COMPLIANCE INSPECTIONS PERFORMED?

	The managing director or chief executive officer?			
	Yes	**No**	**No reply**	**Total**
Africa	0	5	0	5
Asia-Pacific	6	24	2	32
Europe	5	20	2	27
Latin America	2	15	0	17
North America	2	6	0	8
Global	**15**	**70**	**4**	**89**
	Other member of the management team?			
	Yes	**No**	**No reply**	**Total**
Africa	0	5	0	5
Asia-Pacific	15	15	2	32
Europe	9	16	2	27
Latin America	4	13	0	17
North America	2	6	0	8
Global	**30**	**55**	**4**	**89**
	The radiation protection officer?			
	Yes	**No**	**No reply**	**Total**
Africa	4	1	0	5
Asia-Pacific	25	4	3	32
Europe	24	2	1	27
Latin America	15	2	0	17
North America	8	0	0	8
Global	**76**	**9**	**4**	**89**
	Other radiation protection expert?			
	Yes	**No**	**No reply**	**Total**
Africa	2	3	0	5
Asia-Pacific	8	21	3	32
Europe	16	9	2	27
Latin America	7	9	1	17
North America	3	5	0	8
Global	**36**	**47**	**6**	**89**

TABLE 175. FURTHER ANALYSIS OF RESPONSES TO QUESTION 20c — WHO PERFORMS THESE INSPECTIONS?

	Management presence	RPO only	RPE only	Management only[1]	RPO and/or RPE only[2]
Africa	0	3	1	0	5
Asia-Pacific	17	9	1	4	13
Europe	11	6	0	1	15
Latin America	4	8	0	2	13
North America	4	2	0	0	4
Global	**36**	**28**	**2**	**7**	**50**

[1] No RPO or RPE is present at the inspections.
[2] No management team person is present at the inspections.
RPE means radiation protection expert.

TABLE 176. RESPONSES TO QUESTION 20d — IF YES TO QUESTION 20, APPROXIMATELY HOW MANY TIMES PER YEAR WOULD A RADIOGRAPHER BE INSPECTED BY YOUR COMPANY?

	Number of times per year a radiographer would be inspected by the company							No reply
	Data	Mean	Min	Q1	Median	Q3	Max	
Africa	4	2.4	1	1	1.25	2.6	6	1
Asia-Pacific	27	6.5	1	2	4	12	24	5
Europe	22	2.4	0.1	1	2	3	12	5
Latin America	17	3.1	1	2	2	3	12	0
North America	8	2.3	1	1.75	2	2.5	4	0
Global	**78**	**4.0**	**0.1**	**1.00**	**2**	**4**	**24**	**11**

TABLE 177. RESPONSES TO QUESTION 20e(i) — IS THE PROPER WEARING OF PASSIVE INDIVIDUAL DOSIMETERS ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	5	0	0	5
Asia-Pacific	28	4	0	32
Europe	26	0	1	27
Latin America	17	0	0	17
North America	8	0	0	8
Global	**84**	**4**	**1**	**89**

TABLE 178. RESPONSES TO QUESTION 20e(ii) — IS THE PROPER WEARING AND USE OF ACTIVE INDIVIDUAL DOSIMETERS ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	5	0	0	5
Asia-Pacific	29	3	0	32
Europe	24	1	2	27
Latin America	15	2	0	17
North America	8	0	0	8
Global	**81**	**6**	**2**	**89**

TABLE 179. RESPONSES TO QUESTION 20e(iii) — IS THE PROPER USE OF SURVEY METERS ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	3	2	0	5
Asia-Pacific	32	0	0	32
Europe	24	2	1	27
Latin America	17	0	0	17
North America	8	0	0	8
Global	**84**	**4**	**1**	**89**

TABLE 180. RESPONSES TO QUESTION 20e(iv) — IS THE PROPER USE OF COLLIMATORS ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	4	1	0	5
Asia-Pacific	29	3	0	32
Europe	23	3	1	27
Latin America	15	2	0	17
North America	8	0	0	8
Global	**79**	**9**	**1**	**89**

TABLE 181. RESPONSES TO QUESTION 20e(v) — IS THE USE OF AN APPROPRIATE WARNING SYSTEM AT THE WORK SITE ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	3	2	0	5
Asia-Pacific	31	1	0	32
Europe	24	1	2	27
Latin America	15	2	0	17
North America	8	0	0	8
Global	**81**	**6**	**2**	**89**

TABLE 182. RESPONSES TO QUESTION 20e(vi) — DURING COMPANY INSPECTIONS, IS THE DOSE RATE AT THE BOUNDARY OF THE WORK SITE CHECKED TO BE WITHIN THE LIMITS SET?

	Yes	No	No reply	Total
Africa	5	0	0	5
Asia-Pacific	30	2	0	32
Europe	24	2	1	27
Latin America	16	1	0	17
North America	6	2	0	8
Global	**81**	**7**	**1**	**89**

TABLE 183. RESPONSES TO QUESTION 20e(vii) — IS THE USE OF ALARM SYSTEMS (FLASHING LIGHTS, AUDIBLE ALARM, USE OF PA) ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	5	0	0	5
Asia-Pacific	29	3	0	32
Europe	21	5	1	27
Latin America	15	2	0	17
North America	6	2	0	8
Global	**76**	**12**	**1**	**89**

TABLE 184. RESPONSES TO QUESTION 20e(viii) — IS THE PROPER TRAINING AND QUALIFICATIONS OF THE RADIOGRAPHERS ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	4	1	0	5
Asia-Pacific	31	1	0	32
Europe	21	5	1	27
Latin America	16	1	0	17
North America	8	0	0	8
Global	**80**	**8**	**1**	**89**

TABLE 185. RESPONSES TO QUESTION 20e(ix) — IS OPERATOR KNOWLEDGE OF PROCEDURES ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	5	0	0	5
Asia-Pacific	21	11	0	32
Europe	26	0	1	27
Latin America	17	0	0	17
North America	8	0	0	8
Global	**77**	**11**	**1**	**89**

TABLE 186. RESPONSES TO QUESTION 20e(x) — ARE PRE-OPERATION SPECIFIC EQUIPMENT CHECKS ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	4	1	0	5
Asia-Pacific	22	10	0	32
Europe	22	4	1	27
Latin America	16	1	0	17
North America	8	0	0	8
Global	**72**	**16**	**1**	**89**

TABLE 187. RESPONSES TO QUESTION 20e(xi) — IS EQUIPMENT CONDITION ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	5	0	0	5
Asia-Pacific	21	11	0	32
Europe	24	2	1	27
Latin America	17	0	0	17
North America	8	0	0	8
Global	**75**	**13**	**1**	**89**

TABLE 188. RESPONSES TO QUESTION 20e(xii) — IS EMERGENCY PREPAREDNESS ADDRESSED DURING COMPANY INSPECTIONS?

	Yes	No	No reply	Total
Africa	5	0	0	5
Asia-Pacific	21	10	1	32
Europe	16	10	1	27
Latin America	15	1	1	17
North America	7	1	0	8
Global	**64**	**22**	**3**	**89**

In addition to the data in Tables 177–188, there were 15 responses that indicated that additional items were part of their inspections, including: proper documentation, storage, transport, image quality, good practice, vehicle condition, and security.

TABLE 189. ALL REGIONS' RESPONSES TO QUESTION 20f — IF YES TO QUESTION 20, PLEASE RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN COMPANY INSPECTIONS?

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	6	2	5	5	3	68	21	**7**
No proper wearing and use of active individual dosimeters	5	2	2	7	3	70	19	**9**
No proper use of survey meters	8	6	6	6	7	56	33	**3**
No proper use of collimators	8	7	12	5	3	54	35	**1**
No proper warning system to prevent entry to the work site	10	0	5	5	0	69	20	**6**
Dose rate at the boundary of the work site not within limits set	8	12	3	4	7	55	34	**2**
No proper use of alarm systems	3	8	4	1	5	68	21	**7**
No proper training and qualifications of radiographers	1	2	0	2	2	82	7	**12**
Poor operator knowledge of procedures	5	7	6	2	5	64	25	**5**
No pre-operation specific equipment checks being performed	6	7	6	7	3	60	29	**4**
Poor equipment condition	5	4	2	2	3	73	16	**10**
Poor emergency preparedness	1	1	5	3	5	74	15	**11**
Other	1	1	0	0	2	85	4	**13**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 190. AFRICAN REGION'S RESPONSES TO QUESTION 20f — IF YES TO QUESTION 20, PLEASE RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN COMPANY INSPECTIONS?

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	1	0	0	0	0	4	1	**5**
No proper wearing and use of active individual dosimeters	0	0	0	2	0	3	2	**8**
No proper use of survey meters	0	0	0	0	0	5	0	**10**
No proper use of collimators	0	1	0	0	0	4	1	**8**
No proper warning system to prevent entry to the work site	2	0	0	0	0	3	2	**1**
Dose rate at the boundary of the work site not within limits set	1	1	0	0	0	3	2	**2**
No proper use of alarm systems	0	1	0	0	1	3	1	**5**
No proper training and qualifications of radiographers	0	0	0	0	0	5	0	**10**
Poor operator knowledge of procedures	0	0	1	0	2	2	3	**5**
No pre-operation specific equipment checks being performed	0	0	0	0	0	5	0	**10**
Poor equipment condition	0	1	0	1	0	3	2	**4**
Poor emergency preparedness	0	0	3	0	0	2	3	**2**
Other	0	0	0	0	0	5	0	**10**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 191. ASIA-PACIFIC REGION'S RESPONSES TO QUESTION 20f — IF YES TO QUESTION 20, PLEASE RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN COMPANY INSPECTIONS?

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	2	1	2	0	1	26	5	**8**
No proper wearing and use of active individual dosimeters	5	1	1	3	1	21	11	**5**
No proper use of survey meters	2	3	3	3	4	17	15	**4**
No proper use of collimators	3	4	4	4	1	16	16	**1**
No proper warning system to prevent entry to the work site	2	0	4	1	0	25	7	**7**
Dose rate at the boundary of the work site not within limits set	5	2	2	2	3	18	14	**2**
No proper use of alarm systems	2	5	3	1	3	18	14	**3**
No proper training and qualifications of radiographers	1	1	0	0	1	29	3	**11**
Poor operator knowledge of procedures	1	2	0	1	1	27	5	**9**
No pre-operation specific equipment checks being performed	2	2	2	4	0	22	10	**6**
Poor equipment condition	1	1	0	1	1	28	4	**10**
Poor emergency preparedness	0	1	0	1	2	28	4	**12**
Other	0	0	0	0	1	31	1	**13**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 192. EUROPEAN REGION'S RESPONSES TO QUESTION 20f — IF YES TO QUESTION 20, PLEASE RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN COMPANY INSPECTIONS?

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	2	0	2	2	1	20	7	**8**
No proper wearing and use of active individual dosimeters	0	1	1	1	1	23	4	**10**
No proper use of survey meters	3	1	2	3	1	17	10	**2**
No proper use of collimators	2	1	3	1	1	19	8	**4**
No proper warning system to prevent entry to the work site	4	0	0	1	0	22	5	**6**
Dose rate at the boundary of the work site not within limits set	1	7	1	0	2	16	11	**1**
No proper use of alarm systems	1	0	1	0	1	24	3	**11**
No proper training and qualifications of radiographers	0	0	0	2	1	24	3	**12**
Poor operator knowledge of procedures	1	2	4	0	1	19	8	**4**
No pre-operation specific equipment checks being performed	0	4	1	1	1	20	7	**6**
Poor equipment condition	4	1	1	0	0	21	6	**3**
Poor emergency preparedness	1	0	1	2	2	21	6	**9**
Other	0	0	0	0	0	27	0	**13**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 193. LATIN AMERICA REGION'S RESPONSES TO QUESTION 20f — IF YES TO QUESTION 20, PLEASE RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN COMPANY INSPECTIONS?

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	1	1	0	3	1	11	6	**4**
No proper wearing and use of active individual dosimeters	0	0	0	1	1	15	2	**11**
No proper use of survey meters	1	2	0	0	1	13	4	**5**
No proper use of collimators	2	1	4	0	0	10	7	**2**
No proper warning system to prevent entry to the work site	2	0	1	0	0	14	3	**6**
Dose rate at the boundary of the work site not within limits set	1	0	0	2	1	13	4	**7**
No proper use of alarm systems	0	2	0	0	0	15	2	**8**
No proper training and qualifications of radiographers	0	1	0	0	0	16	1	**10**
Poor operator knowledge of procedures	1	2	1	1	0	12	5	**3**
No pre-operation specific equipment checks being performed	3	1	2	0	2	9	8	**1**
Poor equipment condition	0	0	1	0	2	14	3	**9**
Poor emergency preparedness	0	0	0	0	1	16	1	**12**
Other	0	0	0	0	0	17	0	**13**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 194. NORTH AMERICAN REGION'S RESPONSES TO QUESTION 20f — IF YES TO QUESTION 20, PLEASE RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN COMPANY INSPECTIONS?

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	0	0	1	0	0	7	1	**9**
No proper wearing and use of active individual dosimeters	0	0	0	0	0	8	0	**11**
No proper use of survey meters	2	0	1	0	1	4	4	**2**
No proper use of collimators	1	0	1	0	1	5	3	**5**
No proper warning system to prevent entry to the work site	0	0	0	3	0	5	3	**7**
Dose rate at the boundary of the work site not within limits set	0	2	0	0	1	5	3	**5**
No proper use of alarm systems	0	0	0	0	0	8	0	**11**
No proper training and qualifications of radiographers	0	0	0	0	0	8	0	**11**
Poor operator knowledge of procedures	2	1	0	0	1	4	4	**1**
No pre-operation specific equipment checks being performed	1	0	1	2	0	4	4	**3**
Poor equipment condition	0	1	0	0	0	7	1	**8**
Poor emergency preparedness	0	0	1	0	0	7	1	**9**
Other	1	1	0	0	1	5	3	**4**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 195. COMPARISON OF THE REGIONAL AND GLOBAL FIVE MOST COMMON SHORTCOMINGS, BASED ON DATA IN TABLES 189–194

Shortcoming	Shortcoming ranking in:					
	Africa	Asia-Pacific	Europe	Latin America	North America	Global
No proper wearing of passive individual dosimeters	5	8	8	4	9	**7**
No proper wearing and use of active individual dosimeters	8	5	10	11	11	**9**
No proper use of survey meters	10	4	2	5	2	**3**
No proper use of collimators	8	1	4	2	5	**1**
No proper warning system to prevent entry to the work site	1	7	6	6	7	**6**
Dose rate at the boundary of the work site not within limits set	2	2	1	7	5	**2**
No proper use of alarm systems	5	3	11	8	11	**7**
No proper training and qualifications of radiographers	10	11	12	10	11	**12**
Poor operator knowledge of procedures	5	9	4	3	1	**5**
No pre-operation specific equipment checks being performed	10	6	6	1	3	**4**
Poor equipment condition	4	10	3	9	8	**10**
Poor emergency preparedness	2	12	9	12	9	**11**
Other	10	13	13	13	4	**13**

II.5.11. Regulatory body inspections

TABLE 196. RESPONSES TO QUESTION 21 — DOES THE (RADIATION PROTECTION) REGULATORY BODY PERFORM PLANNED INSPECTIONS OF YOUR COMPANY'S RADIOGRAPHERS ON THE WORK SITE?

	Yes	No	Don't know	No reply	Total
Africa	2	4	1	0	7
Asia-Pacific	27	5	1	0	33
Europe	17	9	2	0	28
Latin America	9	10	0	0	19
North America	5	3	0	0	8
Global	**60**	**31**	**4**	**0**	**95**

TABLE 197. RESPONSES TO QUESTION 21a — IF YES TO QUESTION 21, HOW MANY TIMES (ON AVERAGE) WOULD A RADIOGRAPHER UNDERGO A PLANNED INSPECTION BY THE REGULATORY BODY?

	Approximate number times a year a radiographer undergoes a planned RB inspection							No reply
	Data	Mean	Min	Q1	Median	Q3	Max	
Africa	1	2.0	-	-	-	-	-	1
Asia-Pacific	25	2.5	0.5	1	2	4	12	2
Europe	16	1.9	0.1	0.2	1	1	12	1
Latin America	9	1.2	0.5	1	1	1	2	0
North America	5	0.8	0.3	0.5	1	1	1	0
Global	**56**	**2.0**	**0.1**	**1**	**1**	**2**	**12**	**4**

TABLE 198. RESPONSES TO QUESTION 22 — DOES THE (RADIATION PROTECTION) REGULATORY BODY PERFORM UNPLANNED INSPECTIONS OF YOUR COMPANY'S RADIOGRAPHERS ON THE WORK SITE?

	Yes	No	Don't know	No reply	Total
Africa	2	4	1	0	7
Asia-Pacific	20	10	3	0	33
Europe	14	14	0	0	28
Latin America	15	4	0	0	19
North America	7	1	0	0	8
Global	**58**	**33**	**4**	**0**	**95**

TABLE 199. RESPONSES TO QUESTION 22a — IF YES TO QUESTION 22, HOW MANY TIMES (ON AVERAGE) WOULD A RADIOGRAPHER UNDERGO AN UNPLANNED INSPECTION BY THE REGULATORY BODY?

	Approximate number times a year a radiographer undergoes a unplanned RB inspection							No reply
	Data	Mean	Min	Q1	Median	Q3	Max	
Africa	2	2.1	0.2	-	2.1	-	4	0
Asia-Pacific	17	2.7	1	1	2	2	12	3
Europe	13	1.6	0.2	0.3	1	1.5	8	1
Latin America	13	1.1	0.5	10	1	1	2	2
North America	6	0.9	0.2	1	1	1	1	1
Global	**51**	**1.8**	**0.2**	**1**	**1**	**2**	**12**	**7**

TABLE 200. FURTHER ANALYSIS OF RESPONSES TO QUESTIONS 21 & 22 — TYPES OF REGULATORY BODY INSPECTIONS

	Planned inspections only	Unplanned inspections only	Both	Neither form of inspection
Africa	1	1	1	3
Asia-Pacific	9	2	18	3
Europe	9	6	8	5
Latin America	3	9	6	1
North America	1	3	4	0
Global	**23**	**21**	**37**	**12**

TABLE 201. FURTHER ANALYSIS OF RESPONSES TO QUESTIONS 21 & 22 — MEAN NUMBER OF REGULATORY BODY INSPECTIONS A RADIOGRAPHER WOULD UNDERGO PER YEAR

	RB performs both planned and unplanned inspections			
	Data	**Approximate mean number times a year a radiographer undergoes:**		
		A planned RB inspection	**An unplanned RB inspection**	**Any RB inspection**
Africa	1	2.0	4.0	6.0
Asia-Pacific	15	3.0	2.9	6.3
Europe	8	1.6	1.6	3.3
Latin America	6	0.9	0.9	1.8
North America	3	0.7	0.7	1.7
Global	**33**	**2.1**	**2.1**	**4.3**
	RB performs either planned or unplanned or both inspections			
	Data	**Approximate mean number times a year a radiographer undergoes:**		
		A planned RB inspection	**An unplanned RB inspection**	**Any RB inspection**
Africa	2	-	-	3.1
Asia-Pacific	27	-	-	4.0
Europe	21	-	-	2.4
Latin America	16	-	-	1.5
North America	8	-	-	1.1
Global	**74**	**-**	**-**	**2.7**

II.6. EMERGENCY PREPAREDNESS AND RESPONSE

II.6.1. Emergency plans

TABLE 202. RESPONSES TO QUESTION 23 — DOES YOUR COMPANY HAVE AN EMERGENCY PLAN AND PROCEDURES FOR RESPONDING TO INCIDENTS DURING THE PERFORMANCE OF SITE RADIOGRAPHY?

	Yes	No	Don't know	No reply	Total
Africa	6	0	1	0	7
Asia-Pacific	32	1	0	0	33
Europe	27	1	0	0	28
Latin America	17	2	0	0	19
North America	8	0	0	0	8
Global	**90**	**4**	**1**	**0**	**95**

The four 'no' responses were X ray only NDT companies.

TABLE 203. RESPONSES TO QUESTION 23a(i) — DOES YOUR COMPANY COMMUNICATE AND DISCUSS ITS EMERGENCY PLAN WITH THE COMPANY'S RADIOGRAPHERS?

	Yes	No	Don't know	No reply	Total
Africa	5	0	1	0	6
Asia-Pacific	31	1	0	0	32
Europe	22	4	0	1	27
Latin America	16	0	0	1	17
North America	8	0	0	0	8
Global	**82**	**5**	**1**	**2**	**90**

TABLE 204. RESPONSES TO QUESTION 23a(ii) — DOES YOUR COMPANY COMMUNICATE AND DISCUSS ITS EMERGENCY PLAN WITH THE COMPANY'S CLIENTS?

	Yes	No	Don't know	No reply	Total
Africa	1	5	0	0	6
Asia-Pacific	25	7	0	0	32
Europe	5	17	1	4	27
Latin America	8	8	0	1	17
North America	3	5	0	0	8
Global	**42**	**42**	**1**	**5**	**90**

TABLE 205. RESPONSES TO QUESTION 23a(iii) — DOES YOUR COMPANY COMMUNICATE AND DISCUSS ITS EMERGENCY PLAN WITH THE REGULATORY BODY?

	Yes	No	Don't know	No reply	Total
Africa	3	2	1	0	6
Asia-Pacific	28	3	1	0	32
Europe	18	5	0	4	27
Latin America	14	2	0	1	17
North America	6	1	0	1	8
Global	**69**	**13**	**2**	**6**	**90**

TABLE 206. RESPONSES TO QUESTION 23a(iv) — DOES YOUR COMPANY COMMUNICATE AND DISCUSS ITS EMERGENCY PLAN WITH OTHER EMERGENCY RESPONSE AUTHORITIES?

	Yes	No	Don't know	No reply	Total
Africa	2	4	0	0	6
Asia-Pacific	16	14	2	0	32
Europe	5	17	1	4	27
Latin America	10	4	0	3	17
North America	3	4	0	1	8
Global	**36**	**43**	**3**	**8**	**90**

In addition to the data in Tables 203–206, 26 NDT companies said that they communicated and discussed their emergency plan with all of the above parties. No NDT company responded in the negative for all of the above parties — i.e. all 90 responding NDT companies communicated and discussed the emergency plan with at least one of the above parties.

II.6.2. Training on emergency preparedness and response

TABLE 207. RESPONSES TO QUESTION 24 — DOES YOUR COMPANY PROVIDE SPECIFIC TRAINING TO ITS RADIOGRAPHERS ON EMERGENCY PREPAREDNESS AND RESPONSE?

	Yes	No	Don't know	No reply	Total
Africa	4	2	1	0	7
Asia-Pacific	33	0	0	0	33
Europe	15	13	0	0	28
Latin America	18	1	0	0	19
North America	8	0	0	0	8
Global	**78**	**16**	**1**	**0**	**95**

Notes:

1. The 16 'no' answers were dominated by the 13 from Europe. It is likely that these responses reflect the practice and requirements to use specialist persons in emergency roles, and hence training radiographers for this role is not considered appropriate.

2. Cross-correlating the 16 'no ' answers with Question 1c on 'radiation protection training' (Tables 84–86) showed that 11 had stated that they included training in emergency procedures, 6 included practical exercises for creating a safe situation, and 2 included practical exercises in source recovery.

3. See also responses for Question 24a(iii) in the Table 210, below.

TABLE 208. RESPONSES TO QUESTION 24a(i) — IF YES TO QUESTION 24, DOES THE TRAINING INCLUDE AN EXPLANATION OF THE EMERGENCY PROCEDURES?

	Yes	No	Don't know	No reply	Total
Africa	4	0	0	0	4
Asia-Pacific	32	0	0	1	33
Europe	15	0	0	0	15
Latin America	18	0	0	0	18
North America	8	0	0	0	8
Global	**77**	**0**	**0**	**1**	**78**

TABLE 209. RESPONSES TO QUESTION 24a(ii) — IF YES TO QUESTION 24, DOES THE TRAINING INCLUDE PRACTICAL EXERCISES ON CONTAINMENT OF THE SITUATION (I.E. KEEPING IT SAFE AND UNDER CONTROL)?

	Yes	No	Don't know	No reply	Total
Africa	3	1	0	0	4
Asia-Pacific	31	1	0	1	33
Europe	11	3	1	0	15
Latin America	17	1	0	0	18
North America	7	1	0	0	8
Global	**69**	**7**	**1**	**1**	**78**

TABLE 210. RESPONSES TO QUESTION 24a(iii) — IF YES TO QUESTION 24, DOES THE TRAINING INCLUDE PRACTICAL EXERCISES ON RECOVERY OF SOURCES?

	Yes	No	Don't know	No reply	Not applicable	Total
Africa	2	1	1	0	0	4
Asia-Pacific	27	5	0	1	0	33
Europe	7	8	0	0	0	15
Latin America	13	1	0	0	4	18
North America	4	4	0	0	0	8
Global	**53**	**19**	**1**	**1**	**4**	**78**

Note: Cross-correlating the 19 'no' answers for practical exercises on source recovery with Question 1c(iii) on 'radiation protection training' (Table 86) showed that 6 of the 19 had stated that they included practical exercises in source recovery in the radiation protection training, while 12 had not. One had not responded to Question 1c(iii).

II.6.3. Emergency equipment

TABLE 211. RESPONSES TO QUESTION 25 — DOES YOUR COMPANY HAVE EMERGENCY EQUIPMENT FOR SITE RADIOGRAPHY?

	Yes	No	Don't know	No reply	Not applicable	Total
Africa	6	1	0	0	0	7
Asia-Pacific	33	0	0	0	0	33
Europe	22	6	0	0	0	28
Latin America	16	1	0	0	2	19
North America	8	0	0	0	0	8
Global	**85**	**8**	**0**	**0**	**2**	**95**

Note: Of the 8 'no' responses, three were for X ray only NDT companies. The others were again reflecting the role of specialist emergency response personnel in some countries.

TABLE 212. RESPONSES TO QUESTION 25a — IF YES TO QUESTION 25, WHAT EQUIPMENT DOES YOUR COMPANY HAVE?

	Long tongs?				
	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	5	0	1	0	6
Asia-Pacific	29	3	0	1	33
Europe	19	3	0	0	22
Latin America	14	1	0	1	16
North America	7	1	0	0	8
Global	**74**	**8**	**1**	**2**	**85**
	Shielding material?				
	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	5	0	0	1	6
Asia-Pacific	32	0	0	1	33
Europe	21	1	0	0	22
Latin America	15	0	0	1	16
North America	7	1	0	0	8
Global	**80**	**2**	**0**	**3**	**85**
	Emergency/rescue container?				
	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	3	1	1	1	6
Asia-Pacific	29	3	0	1	33
Europe	15	6	0	1	22
Latin America	14	1	0	1	16
North America	3	5	0	0	8
Global	**64**	**16**	**1**	**4**	**85**

Note. There were 20 responses to other equipment, including: protective clothing (6), cutting equipment (6), additional survey meters (long handled) and dosimeters (4), fire extinguishers (2), first aid kit (1), and toolbox (1).

TABLE 213. RESPONSES TO QUESTION 25b — IF YES TO QUESTION 25, DO YOUR RADIOGRAPHERS HAVE ACCESS TO THE EMERGENCY EQUIPMENT?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	5	1	0	0	6
Asia-Pacific	31	2	0	0	33
Europe	18	3	0	1	22
Latin America	16	0	0	0	16
North America	7	1	0	0	8
Global	**77**	**7**	**0**	**1**	**85**

TABLE 214. RESPONSES TO QUESTION 26 — IN YOUR COMPANY'S EMERGENCY PLAN, WHO IS RESPONSIBLE FOR THE FOLLOWING STAGES OF AN EMERGENCY?

	Radiographer	RPO or RPE	Other qualified expert	Authorities	Appointed institute	No. of NDT company responses
	Containment of the situation, i.e. keeping it safe and under control:					
Africa	5	3	1	0	0	6
Asia-Pacific	20	27	2	4	3	31
Europe	25	20	2	5	1	27
Latin America	11	13	6	3	0	17
North America	8	5	0	0	0	8
Global	**69**	**68**	**11**	**12**	**4**	**89**
	Planning and rehearsing the recovery:					
Africa	1	6	1	0	0	6
Asia-Pacific	15	29	2	4	4	30
Europe	9	21	3	9	7	26
Latin America	8	13	5	2	0	16
North America	5	6	1	0	1	8
Global	**38**	**75**	**12**	**15**	**12**	**86**
	Recovery of the situation:					
Africa	3	4	1	0	0	6
Asia-Pacific	16	28	4	5	3	30
Europe	7	16	3	10	7	26
Latin America	9	13	5	3	1	17
North America	5	6	1	1	1	8
Global	**40**	**67**	**14**	**19**	**12**	**87**
	Investigation and reporting:					
Africa	1	4	1	1	0	5
Asia-Pacific	10	28	3	10	2	31
Europe	11	24	1	5	1	26
Latin America	4	15	1	1	0	17
North America	4	6	2	1	1	8
Global	**30**	**77**	**8**	**18**	**4**	**87**

In Table 214 for containment of the situation, 68 NDT companies stated either the radiographer or RPO or both were responsible, and not another qualified expert, authority or institute. Conversely, there were no responses where the radiographer or RPO were not involved.

In Table 214 for planning and rehearsing the recovery, 56 NDT companies stated either the radiographer or RPO or both were responsible, and not another qualified expert, authority or institute. Conversely, there were 4 responses where the radiographer or RPO were not involved.

In Table 214 for recovery of the situation, 52 NDT companies stated either the radiographer or RPO or both were responsible, and not another qualified expert, authority or institute. Conversely, there were 3 responses where the radiographer or RPO were not involved.

In Table 214 for investigation and reporting, 61 NDT companies stated either the radiographer or RPO or both were responsible, and not another qualified expert, authority or institute. Conversely, there were 3 responses where the radiographer or RPO were not involved.

In Table 214, 'other qualified experts' included: recovery specialists, company inspectors, company rescue personnel, and manufacturer's specialist. 'Authorities' included: the regulatory body, police and fire brigade. 'Appointed institutes' included: technical service organizations and the device manufacturer.

TABLE 215. RESPONSES TO QUESTION 27 — DOES YOUR COMPANY HOLD EMERGENCY EXERCISES TO TEST THE CRITICAL COMPONENTS OF THE COMPANY'S EMERGENCY PLAN?

	Yes	**No**	**Don't know**	**No reply**	**Total**
Africa	2	3	0	1	6
Asia-Pacific	24	4	2	2	32
Europe	10	16	1	0	27
Latin America	11	6	0	0	17
North America	2	6	0	0	8
Global	**49**	**35**	**3**	**3**	**90**

TABLE 216. RESPONSES TO QUESTION 27a — IF YES TO QUESTION 27, HOW OFTEN DOES YOUR COMPANY HOLD THESE EXERCISES?

	Number of exercises per year							**No reply**
	Data	**Mean**	**Min**	**Q1**	**Median**	**Q3**	**Max**	
Africa	2	2.5	1	-	2.5	-	4	0
Asia-Pacific	24	2.4	1	1	1.75	2.3	12	0
Europe	10	1.3	1	1	1.0	1.4	2	0
Latin America	11	1.6	1	1	1.0	2	3	0
North America	2	1.5	1	-	1.5	-	2	0
Global	**49**	**2.0**	**1**	**1**	**1**	**2**	**12**	**0**

TABLE 217. RESPONSES TO QUESTION 28 — DOES YOUR COMPANY UNDERTAKE A PERIODIC FORMAL REVIEW OF ITS EMERGENCY PLAN?

	Yes	No	Don't know	No reply	Total
Africa	1	2	2	1	6
Asia-Pacific	24	2	3	3	32
Europe	15	10	2	0	27
Latin America	10	7	0	0	17
North America	4	4	0	0	8
Global	**54**	**25**	**7**	**4**	**90**

TABLE 218. RESPONSES TO QUESTION 28a — IF YES TO QUESTION 28, HOW OFTEN DOES YOUR COMPANY UNDERTAKE A REVIEW?

	Number of reviews per year							No reply
	Data	Mean	Min	Q1	Median	Q3	Max	
Africa	1	2.0	-	-	2	-	-	0
Asia-Pacific	24	1.4	1	1	1	2	3	0
Europe	14	1.0	0.2	1	1	1	2	1
Latin America	7	1.3	1	1	1	1.5	2	3
North America	4	0.7	0.3	0.5	0.75	1	1	0
Global	**50**	**1.2**	**0.2**	**1**	**1**	**1**	**3**	**4**

II.7. NDT COMPANY PROFILES

II.7.1. Radiographic techniques

TABLE 219. RESPONSES TO QUESTION 29 — WHAT RADIOGRAPHIC TECHNIQUES DOES YOUR COMPANY UTILIZE?

	Gamma only	X ray only	Both	No reply	Total
Africa	2	1	4	0	7
Asia-Pacific	3	1	29	0	33
Europe	2	2	24	0	28
Latin America	4	4	11	0	19
North America	3	0	5	0	8
Global	**14**	**8**	**73**	**0**	**95**

II.7.2. Number of industrial radiographers

TABLE 220. RESPONSES TO QUESTION 30a, GIVING STATISTICS ON THE NUMBER OF FULL–TIME INDUSTRIAL RADIOGRAPHERS EMPLOYED BY THE RESPONDING NDT COMPANIES

	Replies	Number of full-time radiographers per NDT company					
		Mean	Min	Q1	Median	Q3	Max
Africa	5	7.0	1	1	5	8	20
Asia-Pacific	23	36.7	7	15	24	32.5	200
Europe	28	40.8	0	5	16.5	45	300
Latin America	18	31.4	3	7	15	41	132
North America	8	78.5	2	4	34	68	400
Global	**82**	**39.2**	**0**	**7**	**17**	**45**	**400**

TABLE 221. RESPONSES TO QUESTION 30a, GIVING THE NUMBER OF NDT COMPANIES WHOSE NUMBER OF FULL–TIME INDUSTRIAL RADIOGRAPHERS, N, ARE IN THE FOLLOWING BANDS

	Replies	Number of NDT companies whose number of full–time radiographers, N, are in the following bands:						
		N=0	0<N<5	5≤N<10	10≤N<20	20≤N<50	50≤N<100	N≥100
Africa	5	0	2	2	0	1	0	0
Asia-Pacific	23	0	0	3	6	9	3	2
Europe	28	1	5	6	3	7	2	4
Latin America	18	0	2	4	4	4	3	1
North America	8	0	3	1	0	0	3	1
Global	**82**	**1**	**12**	**16**	**13**	**21**	**11**	**8**

TABLE 222. RESPONSES TO QUESTION 30a, GIVING THE NUMBER OF PART–TIME INDUSTRIAL RADIOGRAPHERS EMPLOYED BY THE RESPONDING NDT COMPANIES

	Replies	Number of part-time radiographers per NDT company					
		Mean	Min	Q1	Median	Q3	Max
Africa	4	0.3	0	0	0	0.3	1
Asia-Pacific	23	0.9	0	0	0	0	6
Europe	28	7.7	0	0	0	0	90
Latin America	18	0.5	0	0	0	0	5
North America	8	0.4	0	0	0	0	3
Global	**81**	**3.1**	**0**	**0**	**0**	**0**	**90**

Note: Most replies (67 out of 81) were that part–time radiographers were not employed in the NDT company.

TABLE 223. RESPONSES TO QUESTION 30a, GIVING THE NUMBER OF NDT COMPANIES WHOSE NUMBER OF PART–TIME INDUSTRIAL RADIOGRAPHERS, N_P, ARE IN THE FOLLOWING BANDS

	Replies	Number of NDT companies whose number of part–time radiographers, N_P, are in the following bands:						
		$N_P=0$	$0<N_P<5$	$5\leq N_P<10$	$10\leq N_P<20$	$20\leq N_P<50$	$50\leq N_P<100$	$N_P\geq 100$
Africa	4	3	1	0	0	0	0	0
Asia-Pacific	23	18	2	3	0	0	0	0
Europe	28	23	0	1	1	1	2	0
Latin America	18	16	1	1	0	0	0	0
North America	8	7	1	0	0	0	0	0
Global	**81**	**67**	**5**	**5**	**1**	**1**	**2**	**0**

Note: Only four NDT companies replied that they employed itinerant industrial radiographers.

TABLE 224. FROM THE RESPONSES TO QUESTION 30b, THE AVERAGE PERCENTAGES OF INDUSTRIAL RADIOGRAPHERS, IN A NDT COMPANY, THAT WORK AT THE COMPANY BASE, CLIENT SITES, OR BOTH

	Replies	Percentage of radiographers in a NDT company who work at the company base, client site or both:					
		Base		Client sites		Base and client sites	
		Mean	SD	Mean	SD	Mean	SD
Africa	5	11.7	16.2	20.0	44.7	68.3	41.0
Asia-Pacific	19	24.7	37.2	36.4	42.9	39.2	43.8
Europe	25	14.1	28.5	26.5	40.6	59.9	44.7
Latin America	17	39.9	48.4	25.7	39.7	34.4	46.2
North America	8	6.6	11.91	19.1	35.6	74.3	45.9
Global	**74**	**21.8**	**35.8**	**27.6**	**40.1**	**50.8**	**45.8**

Note: the percentages in Table 224 do not necessarily correspond to the relative workloads (i.e. number of exposures) at these locations.

TABLE 225. FROM THE RESPONSES TO QUESTION 30c, THE AVERAGE PERCENTAGES OF INDUSTRIAL RADIOGRAPHERS, IN A NDT COMPANY, THAT PERFORM RADIOGRAPHY WITH GAMMA SOURCES ONLY, X RAY SOURCES ONLY, OR BOTH

	Replies	Percentage of radiographers in a NDT company using gamma sources only, X ray sources only, or both:					
		Gamma only		X ray only		Gamma and X ray	
		Mean	SD	Mean	SD	Mean	SD
Africa	4	50.0	57.7	25.0	50.0	25.0	50.0
Asia-Pacific	23	19.8	35.6	13.4	28.1	63.8	42.2
Europe	26	16.9	34.4	9.1	27.0	71.1	41.0
Latin America	18	23.4	37.6	25.1	41.8	51.5	47.5
North America	8	55.2	47.3	2.2	4.6	42.5	47.4
Global	**79**	**24.8**	**39.1**	**14.1**	**31.5**	**59.5**	**44.6**

There were some inconsistencies in the answers to question 30b and 30c (Tables 224–225). Some responders interpreted the options as being mutually exclusive, while others did not. Hence the values reported in Tables 224–225 must be treated with some caution.

Most of the NDT companies (52 out of 60) reported that their radiographers also performed non-radiographic NDT methods.

II.7.3. Radiation protection officer

TABLE 226. RESPONSES TO QUESTION 31 — DOES YOUR COMPANY HAVE A RADIATION PROTECTION OFFICER OR RADIATION PROTECTION EXPERT INCLUDED IN ITS ORGANIZATION?

	Yes	No	Don't know	No reply	Total
Africa	5	1	0	1	7
Asia-Pacific	33	0	0	0	33
Europe	26	2	0	0	28
Latin America	19	0	0	0	19
North America	8	0	0	0	8
Global	**91**	**3**	**0**	**1**	**95**

TABLE 227. RESPONSES TO QUESTION 31a — IF YES TO QUESTION 31, DOES HE/SHE REPORT DIRECTLY TO THE MANAGING DIRECTOR?

	Yes	No	Don't know	No reply	Total
Africa	1	1	2	1	5
Asia-Pacific	29	2	1	1	33
Europe	22	4	0	0	26
Latin America	18	1	0	0	19
North America	8	0	0	0	8
Global	**78**	**8**	**3**	**2**	**91**

APPENDIX III. DETAILED RESULTS OF THE QUESTIONNAIRE ON OCCUPATIONAL RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY ADDRESSED TO REGULATORY BODIES

III.1. INTRODUCTION

The principal findings from the regulatory body (RB) questionnaire are given in Section 2.3, together with results from the other questionnaires. Appendix III gives additional data in the form of tables and figures. Many of the table headings refer to a specific question number in the regulatory body questionnaire. For reference, the questions from the questionnaire are given in Appendix IV.

As in all appendices and the main document, the term regulatory body refers to the regulatory body responsible for regulating radiation protection. As used elsewhere, the term 'operator' is synonymous with 'radiographer'. The abbreviation RP is often used for 'radiation protection' in the following tables and figures. In many of the tables and figures, 'Min' means minimum, 'Q1' means first quartile, 'Q3' means third quartile, 'Max' means maximum, and 'SD' means standard deviation.

Note, not all questions were answered by all responders.

III.2. NUMBER OF RESPONSES FROM REGULATORY BODIES

TABLE 228. NUMBER OF REGULATORY BODIES CONTACTED, AND NUMBERS AND PERCENTAGES (IN PARENTHESES) OF RESPONSES RECEIVED; AND THE WORLD POPULATION REPRESENTED

Region	Countries contacted	Countries responded	RBs contacted	RB responses *	Total regional population, 10^6	Total population of responding countries, 10^6 *
Africa	35	8	35	8 (23)	980	205 (21)
Asia-Pacific	27	13	35	16 (46)	3750	1660 (44)
Europe	49	27	49	27 (55)	900	255 (28)
Latin America	20	5	20	5 (25)	580	188 (32)
North America	2	2	3	3 (100)	350	350 (100)
Global	**133**	**55**	**142**	**59**	**6560**	**2650 (40)**

* Values in parentheses are percentages of the corresponding total.

III.3. TRAINING AND QUALIFICATIONS OF INDUSTRIAL RADIOGRAPHERS

III.3.1. Initial radiation protection training

TABLE 229. RESPONSES TO QUESTION 1 — DOES THE REGULATORY BODY REQUIRE THAT PERSONS WISHING TO PERFORM ON-SITE RADIOGRAPHY MUST HAVE HAD RADIATION PROTECTION TRAINING TO AN ACCEPTABLE LEVEL?

	Yes	No	Don't know	No reply	Total
Africa	8	0	0	0	8
Asia-Pacific	16	0	0	0	16
Europe	26	1	0	0	27
Latin America	5	0	0	0	5
North America	3	0	0	0	3
Global	**58**	**1**	**0**	**0**	**59**

TABLE 230. RESPONSES TO QUESTION 1a(i) — IF YES TO QUESTION 1, DOES THE REGULATORY BODY CONSIDER AS ACCEPTABLE, RADIATION PROTECTION TRAINING THAT IS PART OF NDT–TRAINING ON RADIOGRAPHIC TESTING?

	Yes	No	Don't know	No reply	Total
Africa	6	0	0	2	8
Asia-Pacific	10	4	0	2	16
Europe	15	7	1	3	26
Latin America	1	3	0	1	5
North America	3	0	0	0	3
Global	**35**	**14**	**1**	**8**	**58**

TABLE 231. RESPONSES TO QUESTION 1a(ii) — IF YES TO QUESTION 1, DOES THE REGULATORY BODY CONSIDER AS ACCEPTABLE, RADIATION PROTECTION TRAINING THAT IS A SEPARATE TRAINING COURSE?

	Yes	No	Don't know	No reply	Total
Africa	4	2	0	2	8
Asia-Pacific	12	2	0	2	16
Europe	20	4	1	1	26
Latin America	5	0	0	0	5
North America	2	1	0	0	3
Global	**43**	**9**	**1**	**5**	**58**

TABLE 232. RESPONSES TO QUESTION 1b — IF YES TO QUESTION 1, DOES THE REGULATORY BODY HAVE THE SAME RADIATION PROTECTION TRAINING REQUIREMENTS FOR USING GAMMA SOURCES AS FOR USING X RAY MACHINES?

	Yes	No	Don't know	No reply	Total
Africa	5	2	0	1	8
Asia-Pacific	14	1	1	0	16
Europe	20	4	0	2	26
Latin America	4	0	1	0	5
North America	0	0	1	2	3
Global	**43**	**7**	**3**	**5**	**58**

TABLE 233. RESPONSES TO QUESTION 1c — IF YES TO QUESTION 1, DOES THE REGULATORY BODY REQUIRE THAT THE RADIATION PROTECTION TRAINING INCLUDES BOTH THEORETICAL AND PRACTICAL TRAINING?

	Yes	No	Don't know	No reply	Total
Africa	7	1	0	0	8
Asia-Pacific	13	3	0	0	16
Europe	24	2	0	0	26
Latin America	5	0	0	0	5
North America	2	1	0	0	3
Global	**51**	**7**	**0**	**0**	**58**

TABLE 234. RESPONSES TO QUESTION 1d(i) — IF YES TO QUESTION 1, DOES THE REGULATORY BODY REQUIRE THAT THE RADIATION PROTECTION TRAINING INCLUDES PRACTICAL EXERCISES FOR EMERGENCIES FOR CREATING A SAFE SITUATION UNTIL THE SOURCE IS ABLE TO BE RECOVERED?

	Yes	No	Don't know	No reply	Total
Africa	7	1	0	0	8
Asia-Pacific	12	4	0	0	16
Europe	15	8	3	0	26
Latin America	5	0	0	0	5
North America	2	0	0	1	3
Global	**41**	**13**	**3**	**1**	**58**

TABLE 235. RESPONSES TO QUESTION 1d(ii) — IF YES TO QUESTION 1, DOES THE REGULATORY BODY REQUIRE THAT THE RADIATION PROTECTION TRAINING INCLUDES PRACTICAL EXERCISES FOR EMERGENCIES FOR SOURCE RECOVERY?

	Yes	No	Don't know	No reply	Total
Africa	5	2	0	1	8
Asia-Pacific	11	4	0	1	16
Europe	11	11	3	1	26
Latin America	5	0	0	0	5
North America	2	0	0	1	3
Global	**34**	**17**	**3**	**4**	**58**

TABLE 236. RESPONSES TO QUESTION 1e — IF YES TO QUESTION 1, DOES HAVING THE ACCEPTABLE LEVEL OF RADIATION PROTECTION TRAINING (EITHER AS PART OF THE NDT PROGRAMME OR AS SEPARATE TRAINING) INCLUDE HAVING PASSED AN EXAMINATION AT THE END OF THE RADIATION PROTECTION TRAINING?

	Yes	No	Don't know	No reply	Total
Africa	6	2	0	0	8
Asia-Pacific	14	1	0	1	16
Europe	22	3	1	0	26
Latin America	5	0	0	0	5
North America	3	0	0	0	3
Global	**50**	**6**	**1**	**1**	**58**

TABLE 237. RESPONSES TO QUESTION 1f — IF YES TO QUESTION 1e, IS THE EXAMINATION ON RADIATION PROTECTION: THEORETICAL ONLY, PRACTICAL ONLY, OR BOTH THEORETICAL AND PRACTICAL?

	Theory only	Practical only	Both theory & practical	No reply	Total
Africa	0	0	5	1	6
Asia-Pacific	8	0	6	0	14
Europe	11	0	11	0	22
Latin America	2	0	3	0	5
North America	1	0	2	0	3
Global	**22**	**0**	**27**	**1**	**50**

TABLE 238. RESPONSES TO QUESTION 1g — IF YES TO QUESTION 1a(ii), ARE THE SEPARATE TRAINING COURSES CONDUCTED BY: THE REGULATORY BODY, EDUCATIONAL INSTITUTES, PRIVATE NDT COMPANIES, PRIVATE RADIATION PROTECTION CONSULTANTS, OR OTHER?

	Number of RBs who consider separate RP training as acceptable	Acceptable as RP training providers — number of 'yes' responses:			
		RB	Educational institutes	Private NDT companies	Private RP consultants
Africa	4	4	2	1	2
Asia-Pacific	12	6	8	8	3
Europe	20	5	10	7	11
Latin America	5	2	2	1	2
North America	2	1	2	2	2
Global	**43**	**18**	**24**	**19**	**20**

Several responses indicated that the 'course provider' needed to be authorized or approved by the regulatory body. A few regulatory bodies indicated that they recognized training by some other specified countries.

III.3.2. Refresher radiation protection training

TABLE 239. RESPONSES TO QUESTION 2 — DOES THE REGULATORY BODY REQUIRE REFRESHER TRAINING IN RADIATION PROTECTION FOR PERSONS PERFORMING ON–SITE RADIOGRAPHY?

	Yes	No	Don't know	No reply	Total
Africa	6	2	0	0	8
Asia-Pacific	8	8	0	0	16
Europe	22	5	0	0	27
Latin America	3	2	0	0	5
North America	2	1	0	0	3
Global	**41**	**18**	**0**	**0**	**59**

TABLE 240. RESPONSES TO QUESTION 2a — IF YES TO QUESTION 2, WHAT IS THE TIME INTERVAL BETWEEN REFRESHER COURSES?

	Replies	Time interval between refresher course (years)						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	6	3.7	1	3	4	5	5	0
Asia-Pacific	8	3.0	1	1.8	2.5	5	5	0
Europe	19	4.7	1	5	5	5	10	3
Latin America	2	2.0	1	-	2	-	3	1
North America	2	3.0	3	-	3	-	3	0
Global	**37**	**4.0**	**1**	**3**	**5**	**5**	**10**	**4**

TABLE 241. RESPONSES TO QUESTION 2b — IF YES TO QUESTION 2, IS THERE AN EXAMINATION AS PART OF THE REFRESHER TRAINING?

	Yes	No	Don't know	No reply	Total
Africa	1	4	0	1	6
Asia-Pacific	2	5	0	1	8
Europe	14	6	1	1	22
Latin America	3	0	0	0	3
North America	1	0	1	0	2
Global	**21**	**15**	**2**	**3**	**41**

III.3.3. Radiation protection training for an RPO

TABLE 242. RESPONSES TO QUESTION 3 — DOES THE REGULATORY BODY REQUIRE THAT A PERSON WISHING TO ACT AS A RADIATION PROTECTION OFFICER (RPO) FOR A COMPANY THAT PERFORMS ON-SITE RADIOGRAPHY MUST HAVE HAD RADIATION PROTECTION TRAINING TO AN ACCEPTABLE LEVEL?

	Yes	No	Don't know	No reply	Total
Africa	8	0	0	0	8
Asia-Pacific	15	1	0	0	16
Europe	26	1	0	0	27
Latin America	5	0	0	0	5
North America	3	0	0	0	3
Global	**57**	**2**	**0**	**0**	**59**

TABLE 243. RESPONSES TO QUESTION 3a — IF YES TO QUESTION 3, IS THE ACCEPTABLE LEVEL HIGHER THAN THAT FOR AN OPERATOR (AS IN QUESTION 1)?

	Yes	No	Don't know	No reply	Total
Africa	4	4	0	0	8
Asia-Pacific	11	4	0	0	15
Europe	19	6	0	1	26
Latin America	3	2	0	0	5
North America	2	1	0	0	3
Global	**39**	**17**	**0**	**1**	**57**

TABLE 244. RESPONSES TO QUESTION 3b — IF YES TO QUESTION 3, IS THERE AN EXAMINATION AS PART OF THE TRAINING TO BE AN RPO?

	Yes	No	Don't know	No reply	Total
Africa	5	3	0	0	8
Asia-Pacific	10	1	0	4	15
Europe	20	5	0	1	26
Latin America	4	1	0	0	5
North America	3	0	0	0	3
Global	**42**	**10**	**0**	**5**	**57**

III.4. RADIATION INCIDENTS (DEVIATIONS, NEAR MISSES AND ACCIDENTS)

III.4.1. Reporting of radiation incidents

TABLE 245. RESPONSES TO QUESTION 4 — DOES THE REGULATORY BODY REQUIRE THE AUTHORIZED PARTY (LICENSEE) TO REPORT RADIATION INCIDENTS IN INDUSTRIAL RADIOGRAPHY TO THE REGULATORY BODY?

	Yes	No	Don't know	No reply	Total
Africa	7	1	0	0	8
Asia-Pacific	15	1	0	0	16
Europe	27	0	0	0	27
Latin America	3	2	0	0	5
North America	3	0	0	0	3
Global	**55**	**4**	**0**	**0**	**59**

TABLE 246. RESPONSES TO QUESTION 4a — IF YES TO QUESTION 4, WHAT ARE THE CRITERIA FOR REQUIRING A LICENSEE TO NOTIFY THE REGULATORY BODY?

	No. of RBs giving criteria	Number of regulatory bodies stating the following criteria:			
		Lost or stolen source	Source stuck, or equipment malfunction with implications for safety	Event that caused (or could have) significant exposure (workers or public)	Specified in regulations but no details given
Africa	4	2	1	3	1
Asia-Pacific	11	2	1	5	5
Europe	23	10	5	19	4
Latin America	2	1	1	1	1
North America	3	1	2	3	0
Global	**43**	**16**	**10**	**31**	**11**

TABLE 247. RESPONSES TO QUESTION 5a — HOW MANY RADIATION INCIDENTS IN INDUSTRIAL RADIOGRAPHY WITH ELEVATED INDIVIDUAL EXPOSURES HIGHER THAN THE ANNUAL LIMIT WERE NOTIFIED TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Replies	Number of notified accidents with elevated individual exposures higher than the annual dose limits								No reply
		No. of zero notif's*	Total no. of notif's*	Mean	Min	Q1	Median	Q3	Max	
Africa	7	6	1	0.1	0	0	0	0	1	0
Asia-Pacific	12	3	20	1.7	0	0.8	1	1.3	9	3
Europe	25	23	3	0.1	0	0	0	0	2	2
Latin America	3	3	0	0	0	-	0	-	0	0
North America	3	1	10	3.3	0	-	1	-	9	0
Global	**50**	**36**	**34**	**0.7**	**0**	**0**	**0**	**1**	**9**	**5**

* Note: 'notif's' = notifications.

TABLE 248. RESPONSES TO QUESTION 5b — HOW MANY RADIATION INCIDENTS IN INDUSTRIAL RADIOGRAPHY WITH ELEVATED INDIVIDUAL EXPOSURES LOWER THAN THE ANNUAL LIMIT WERE NOTIFIED TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Replies	Number of notified accidents with elevated individual exposures lower than the annual dose limits								No reply
		No. of zero notif's*	Total no. of notif's*	Mean	Min	Q1	Median	Q3	Max	
Africa	7	6	2	0.3	0	0	0	0	2	0
Asia-Pacific	11	3	126	11. 5	0	0.5	1	2.5	113	4
Europe	25	16	50	2.0	0	0	0	2	11	2
Latin America	3	3	0	0	0	-	0	-	0	0
North America	2	1	3	1.5	0	-	1.5	-	3	1
Global	**48**	**29**	**181**	**3.8**	**0**	**0**	**0**	**2**	**113**	**7**

* Note: 'notif's' = notifications.

TABLE 249. RESPONSES TO QUESTION 5c — HOW MANY NEAR MISSES IN INDUSTRIAL RADIOGRAPHY, THAT HAD THE POTENTIAL FOR ELEVATED INDIVIDUAL EXPOSURES HIGHER THAN THE ANNUAL LIMIT, WERE NOTIFIED TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Replies	Number of notified near misses with the potential for elevated individual exposures higher than the annual dose limits								No reply
		No. of zero notif's*	Total no. of notif's*	Mean	Min	Q1	Median	Q3	Max	
Africa	7	7	0	0	0	0	0	0	0	0
Asia-Pacific	11	8	10	0.9	0	0	0	0.5	8	4
Europe	24	19	11	0.5	0	0	0	0	4	3
Latin America	3	2	1	0.3	0	-	0	-	1	0
North America	1	1	0	0	-	-	0	0	0	2
Global	**46**	**37**	**22**	**0.5**	**0**	**0**	**0**	**0**	**8**	**9**

* Note: 'notif's' = notifications.

TABLE 250. RESPONSES TO QUESTION 5d — HOW MANY NEAR MISSES IN INDUSTRIAL RADIOGRAPHY, THAT HAD THE POTENTIAL FOR ELEVATED INDIVIDUAL EXPOSURES LOWER THAN THE ANNUAL LIMIT, WERE NOTIFIED TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Replies	Number of notified near misses with the potential for elevated individual exposures lower than the annual dose limits								No reply
		No. of zero notif's*	Total no. of notif's*	Mean	Min	Q1	Median	Q3	Max	
Africa	7	6	1	0.1	0	0	0	0	1	0
Asia-Pacific	11	9	7	0.6	0	0	0	0	4	4
Europe	24	17	34	1.4	0	0	0	1.3	12	3
Latin America	3	2	4	1.3	0	-	0	-	4	0
North America	1	1	0	0	-	-	0	-	-	2
Global	**46**	**35**	**46**	**1.0**	**0**	**0**	**0**	**0**	**12**	**9**

* Note: 'notif's' = notifications.

TABLE 251. RESPONSES TO QUESTION 5e — HOW MANY OTHER DEVIATIONS FROM NORMAL OPERATIONS IN INDUSTRIAL RADIOGRAPHY WERE NOTIFIED TO THE REGULATORY BODY IN THE LAST FIVE YEARS?

	Replies	Number of notified other deviations from normal operations in industrial radiography								No reply
		No. of zero notif's*	Total no. of notif's*	Mean	Min	Q1	Median	Q3	Max	
Africa	7	5	3	0.4	0	0	0	0.5	2	0
Asia-Pacific	9	7	13	1.4	0	0	0	0	11	6
Europe	24	15	50	2.1	0	0	0	3	12	3
Latin America	2	1	1	0.5	0	-	0.5	-	1	1
North America	2	0	114	57.0	4	-	57	-	110	1
Global	**44**	**28**	**181**	**4.1**	**0**	**0**	**0**	**2**	**110**	**11**

* Note: 'notif's' = notifications.

III.4.2. Radiation incident database

TABLE 252. RESPONSES TO QUESTION 6 — DOES THE REGULATORY BODY MAINTAIN A RADIATION INCIDENT DATABASE FOR YOUR JURISDICTION (COUNTRY OR STATE)?

	Yes	No	Don't know	No reply	Total
Africa	5	3	0	0	8
Asia-Pacific	15	1	0	0	16
Europe	16	10	0	1	27
Latin America	1	4	0	0	5
North America	3	0	0	0	3
Global	**40**	**18**	**0**	**1**	**59**

TABLE 253. RESPONSES TO QUESTION 6a — IF YES TO QUESTION 6, DOES THE REGULATORY BODY ANALYSE THE DATABASE REGULARLY, USING ESTABLISHED CRITERIA, TO DETERMINE IF THERE ARE COMMON FACTORS IN THE INCIDENTS?

	Yes	No	Don't know	No reply	Total
Africa	2	1	0	2	5
Asia-Pacific	7	5	0	3	15
Europe	11	4	0	1	16
Latin America	1	0	0	0	1
North America	2	0	1	0	3
Global	**23**	**10**	**1**	**6**	**40**

TABLE 254. RESPONSES TO QUESTION 6b — IF YES TO QUESTION 6, DOES THE REGULATORY BODY USE THE INTERNATIONAL NUCLEAR AND RADIOLOGICAL EVENT SCALE (INES) TO CLASSIFY THE SEVERITY OF THE INCIDENTS?

	Yes	No	Don't know	No reply	Total
Africa	2	1	0	2	5
Asia-Pacific	8	4	3	0	15
Europe	11	3	0	2	16
Latin America	1	0	0	0	1
North America	1	1	0	1	3
Global	**23**	**9**	**3**	**5**	**40**

TABLE 255. RESPONSES TO QUESTION 6c — IF NO TO QUESTION 6b, DOES THE REGULATORY BODY USE ANOTHER SCALE TO CLASSIFY THE SEVERITY OF THE INCIDENTS?

	Yes	No	Don't know	No reply	Total
Africa	0	1	0	0	1
Asia-Pacific	1	3	0	0	4
Europe	0	3	0	0	3
Latin America	0	0	0	0	0
North America	1	0	0	0	1
Global	**2**	**7**	**0**	**0**	**9**

Two regulatory bodies replied that their regulations specified the scale for use.

III.4.3. Dissemination of information about incidents

TABLE 256. RESPONSES TO QUESTION 7 — DOES THE REGULATORY BODY HAVE AN ESTABLISHED SYSTEM FOR SHARING LESSONS LEARNED FROM REPORTED INCIDENTS, INCLUDING AN ANALYSIS OF THE ROOT CAUSES AND THE CORRECTIVE ACTIONS TAKEN?

	Yes	No	Don't know	No reply	Total
Africa	1	5	0	2	8
Asia-Pacific	9	7	0	0	16
Europe	13	12	0	2	27
Latin America	1	4	0	0	5
North America	3	0	0	0	3
Global	**27**	**28**	**0**	**4**	**59**

TABLE 257. RESPONSES TO QUESTION 7a(i) — IF YES TO QUESTION 7, IS THE INFORMATION DISSEMINATED TO OPERATING NDT COMPANIES IN YOUR JURISDICTION?

	Yes	No	Don't know	No reply	Total
Africa	1	0	0	0	1
Asia-Pacific	6	1	1	1	9
Europe	13	0	0	0	13
Latin America	1	0	0	0	1
North America	3	0	0	0	3
Global	**24**	**1**	**1**	**1**	**27**

TABLE 258. RESPONSES TO QUESTION 7a(ii) — IF YES TO QUESTION 7, IS THE INFORMATION DISSEMINATED TO OTHER REGULATORY BODIES IN OTHER COUNTRIES OR STATES?

	Yes	No	Don't know	No reply	Total
Africa	1	0	0	0	1
Asia-Pacific	0	6	1	2	9
Europe	6	6	0	1	13
Latin America	1	0	0	0	1
North America	2	0	1	0	3
Global	**10**	**12**	**2**	**3**	**27**

TABLE 259. RESPONSES TO QUESTION 7b(i) — IF YES TO QUESTION 7, HOW MANY TIMES IN THE LAST 5 YEARS HAS INFORMATION FROM REPORTED INCIDENTS BEEN DISSEMINATED TO OPERATING NDT COMPANIES IN YOUR JURISDICTION?

	Replies	Number of disseminations to NDT companies							No reply
		Total	Mean	Min	Q1	Median	Q3	Max	
Africa	1	0	0	-	-	0	-	-	0
Asia-Pacific	5	6	1.2	0	0	0	2	4	4
Europe	10	12	1.2	0	0	0.5	2	5	3
Latin America	1	0	0	-	-	0	-	-	0
North America	0	0	-	-	-	-	-	-	3
Global	**17**	**18**	**1.1**	**0**	**0**	**0**	**2**	**5**	**10**

TABLE 260. RESPONSES TO QUESTION 7b(ii) — IF YES TO QUESTION 7, HOW MANY TIMES IN THE LAST 5 YEARS HAS INFORMATION FROM REPORTED INCIDENTS BEEN DISSEMINATED TO REGULATORY BODIES IN OTHER COUNTRIES OR STATES?

	Replies	Number of disseminations to other regulatory bodies							No reply
		Total	Mean	Min	Q1	Median	Q3	Max	
Africa	1	0	0	-	-	0	-	-	0
Asia-Pacific	3	0	0	0	-	0	-	0	6
Europe	10	5	0.5	0	0	0	0	5	3
Latin America	1	0	0	-	-	0	-	-	0
North America	1	86	86	-	-	86	-	-	2
Global	**16**	**91**	**5.7**	**0**	**0**	**0**	**0**	**86**	**11**

TABLE 261. RESPONSES TO QUESTION 8 — IF YOU ARE THE NATIONAL REGULATORY BODY, DID YOU REPORT THE INCIDENTS TO THE INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA) IN THE LAST 5 YEARS?

	Yes	No	Don't know	No reply	Total
Africa	2	5	0	1	8
Asia-Pacific	5	7	0	4	16
Europe	5	16	2	4	27
Latin America	2	3	0	0	5
North America	2	0	1	0	3
Global	**16**	**31**	**3**	**9**	**59**

III.5. SYSTEMS AND PROCEDURES IN PLACE TO ENSURE PROTECTION AND SAFETY IN INDUSTRIAL RADIOGRAPHY

III.5.1. Safety of the radiographer

III.5.1.1. Requirements for individual monitoring

TABLE 262. RESPONSES TO QUESTION 9a — DOES THE REGULATORY BODY REQUIRE THE RADIOGRAPHER TO HAVE A PASSIVE INDIVIDUAL DOSIMETER?

	Yes	No	Don't know	No reply	Total
Africa	6	0	0	2	8
Asia-Pacific	16	0	0	0	16
Europe	26	0	0	1	27
Latin America	5	0	0	0	5
North America	3	0	0	0	3
Global	**56**	**0**	**0**	**3**	**59**

TABLE 263. RESPONSES TO QUESTION 9b — DOES THE REGULATORY BODY REQUIRE THE RADIOGRAPHER TO HAVE AN ACTIVE INDIVIDUAL DOSIMETER?

	Yes	No	Don't know	No reply	Total
Africa	5	2	0	1	8
Asia-Pacific	10	5	1	0	16
Europe	24	1	0	2	27
Latin America	3	2	0	0	5
North America	3	0	0	0	3
Global	**45**	**10**	**1**	**3**	**59**

TABLE 264. RESPONSES TO QUESTION 9c — IF YES TO 9b, IS THE ACTIVE DOSIMETER REQUIRED TO MEASURE INTEGRATED DOSE?

	Yes	No	Don't know	No reply	Total
Africa	3	2	0	0	5
Asia-Pacific	6	1	0	3	10
Europe	14	8	2	0	24
Latin America	3	0	0	0	3
North America	1	2	0	0	3
Global	**27**	**13**	**2**	**3**	**45**

TABLE 265. RESPONSES TO QUESTION 9d(i) — IF YES TO 9b, IS THE ACTIVE DOSIMETER REQUIRED TO HAVE A VISUAL ALARM?

	Yes	No	Don't know	No reply	Total
Africa	2	1	0	2	5
Asia-Pacific	5	5	0	0	10
Europe	14	6	2	2	24
Latin America	1	1	0	1	3
North America	3	0	0	0	3
Global	**25**	**13**	**2**	**5**	**45**

TABLE 266. RESPONSES TO QUESTION 9d(ii) — IF YES TO 9b, IS THE ACTIVE DOSIMETER REQUIRED TOHAVE AN AUDIBLE ALARM?

	Yes	No	Don't know	No reply	Total
Africa	4	1	0	0	5
Asia-Pacific	10	0	0	0	10
Europe	21	1	1	1	24
Latin America	3	0	0	0	3
North America	3	0	0	0	3
Global	**41**	**2**	**1**	**1**	**45**

TABLE 267. RESPONSES TO QUESTION 9d(iii) — IF YES TO 9b, IS THE ACTIVE DOSIMETER REQUIRED TO HAVE A VIBRATING ALARM?

	Yes	No	Don't know	No reply	Total
Africa	0	3	0	2	5
Asia-Pacific	1	8	1	0	10
Europe	7	11	2	4	24
Latin America	0	2	0	1	3
North America	1	2	0	0	3
Global	**9**	**26**	**3**	**7**	**45**

III.5.1.2. Requirements to be informed about occupational doses

TABLE 268. RESPONSES TO QUESTION 10a — DOES THE REGULATORY BODY REQUIRE THAT THE MONITORED RADIOGRAPHERS ARE INFORMED ABOUT THEIR PERSONAL DOSES?

	Yes	No	Don't know	No reply	Total
Africa	4	2	0	2	8
Asia-Pacific	13	2	0	1	16
Europe	20	5	1	1	27
Latin America	4	0	0	1	5
North America	3	0	0	0	3
Global	**44**	**9**	**1**	**5**	**59**

TABLE 269. RESPONSES TO QUESTION 10a(i) — IF YES, HOW MANY TIMES PER YEAR?

	Replies	Number of times per year						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	2	8.0	4	-	8	-	12	2
Asia-Pacific	9	8.7	4	4	12	12	12	4
Europe	16	9.1	1	4	12	12	12	4
Latin America	4	7.3	1	3.3	8	12	12	0
North America	3	2.0	1	-	1	-	4	0
Global	**34**	**8.1**	**1**	**4**	**12**	**12.0**	**12**	**10**

TABLE 270. RESPONSES TO QUESTION 10b — DOES THE REGULATORY BODY REQUIRE THAT THE NDT COMPANY OR EMPLOYER OF THE RADIOGRAPHER IS INFORMED ABOUT THE RADIOGRAPHER'S PERSONAL DOSES?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	1	8
Asia-Pacific	15	1	0	0	16
Europe	23	3	1	0	27
Latin America	5	0	0	0	5
North America	3	0	0	0	3
Global	**53**	**4**	**1**	**1**	**59**

TABLE 271. RESPONSES TO QUESTION 10b(i) — IF YES, HOW MANY TIMES PER YEAR?

	Replies	Number of times per year						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	6	8.3	4	4.5	9	12	12	1
Asia-Pacific	11	7. 5	4	4	6	12	12	4
Europe	19	9.4	1	5	12	12	12	4
Latin America	5	8.2	1	4	12	12	12	0
North America	3	9. 7	1	-	4	-	24	0
Global	**44**	**8.6**	**1**	**4**	**12**	**12**	**24**	**9**

TABLE 272. RESPONSES TO QUESTION 10c — DOES THE REGULATORY BODY REQUIRE THAT IT IS INFORMED ABOUT THE RADIOGRAPHERS' PERSONAL DOSES?

	Yes	No	Don't know	No reply	Total
Africa	4	2	0	2	8
Asia-Pacific	10	4	0	2	16
Europe	18	7	1	1	27
Latin America	4	0	0	1	5
North America	2	1	0	0	3
Global	**38**	**14**	**1**	**6**	**59**

TABLE 273. RESPONSES TO QUESTION 10c(i) — IF YES, HOW MANY TIMES PER YEAR?

	Replies	Number of times per year						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	3	6.3	1	-	6	-	12	1
Asia-Pacific	7	4.1	1	1	4	5	12	3
Europe	15	6.3	1	1	6	12	12	3
Latin America	4	4.5	1	1	2.5	6	12	0
North America	1	1.0	-	-	1	-	-	1
Global	**30**	**5.4**	**1**	**1**	**4**	**12**	**12**	**8**

TABLE 274. RESPONSES TO QUESTION 10d — DOES THE REGULATORY BODY REQUIRE THAT THE NATIONAL PERSNAL DOSE DATABASE IS INFORMED ABOUT THE RADIOGRAPHERS' PERSONAL DOSES?

	Yes	No	Don't know	No reply	Total
Africa	2	3	0	3	8
Asia-Pacific	8	4	1	3	16
Europe	21	3	0	3	27
Latin America	2	2	0	1	5
North America	3	0	0	0	3
Global	**36**	**12**	**1**	**10**	**59**

TABLE 275. RESPONSES TO QUESTION 10d(i) — IF YES, HOW MANY TIMES PER YEAR?

	Replies	Number of times per year						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	0	-	-	-	-	-	-	2
Asia-Pacific	6	6.5	1	4	5	10.5	12	2
Europe	17	7.9	1	2	12	12	12	4
Latin America	2	8.0	4	-	8	-	12	0
North America	2	12.5	1	-	12.5	-	24	1
Global	**27**	**8.0**	**1**	**3**	**12**	**12**	**24**	**9**

III.5.1.3. Requirements for survey meters

TABLE 276. RESPONSES TO QUESTION 11 — DOES THE REGULATORY BODY REQUIRE THAT THE RADIOGRAPHER ALWAYS HAS A FUNCTIONING AND CALIBRATED SURVEY METER WITH THEM?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	1	8
Asia-Pacific	13	0	0	3	16
Europe	24	3	0	0	27
Latin America	5	0	0	0	5
North America	3	0	0	0	3
Global	**52**	**3**	**0**	**4**	**59**

III.5.2. Safety of the public

III.5.2.1. Requirements for advance notification of on-site radiography work

TABLE 277. RESPONSES TO QUESTION 12 — DOES THE REGULATORY BODY REQUIRE THAT IT IS INFORMED IN ADVANCE ABOUT INDIVIDUAL ON-SITE INDUSTRIAL RADIOGRAPHY JOBS?

	Yes	No	Don't know	No reply	Total
Africa	3	4	0	1	8
Asia-Pacific	4	12	0	0	16
Europe	11	16	0	0	27
Latin America	3	1	1	0	5
North America	1	2	0	0	3
Global	**22**	**35**	**1**	**1**	**59**

TABLE 278. RESPONSES TO QUESTION 12a — IF YES TO QUESTION 12, HOW LONG IN ADVANCE MUST THE NOTIFICATION BE (IN HOURS)?

	Replies	Advance notification in hours						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	1	24.0	-	-	24	-	-	2
Asia-Pacific	3	24.0	24	-	24	-	24	1
Europe	10	55.2	24	30	60	72	96	1
Latin America	3	56.0	24	-	24	-	120	0
North America	0	-	-	-	-	-	-	1
Global	**17**	**48.0**	**24**	**24**	**24**	**72**	**120**	**5**

III.5.2.2. Requirements for warning systems to prevent entry

TABLE 279. RESPONSES TO QUESTION 13 — DOES THE REGULATORY BODY REQUIRE THERE TO BE A WARNING SYSTEM TO PREVENT ENTRY TO THE RADIOGRAPHY SITE?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	1	8
Asia-Pacific	16	0	0	0	16
Europe	26	1	0	0	27
Latin America	4	0	1	0	5
North America	3	0	0	0	3
Global	**56**	**1**	**1**	**1**	**59**

TABLE 280. RESPONSES TO QUESTION 13a — IF YES TO QUESTION 13, DOES THE REGULATORY BODY HAVE AN OFFICIAL STANDARD PROCEDURE FOR WARNING SYSTEMS THAT MUST BE FOLLOWED?

	Yes	No	Don't know	No reply	Total
Africa	5	2	0	0	7
Asia-Pacific	16	0	0	0	16
Europe	21	5	0	0	26
Latin America	3	1	0	0	4
North America	2	1	0	0	3
Global	**47**	**9**	**0**	**0**	**56**

TABLE 281. RESPONSES TO QUESTION 13b(i) — IF YES TO QUESTION 13a, DOES THE OFFICIAL STANDARD PROCEDURE FOR A WARNING SYSTEM REQUIRE BARRIERS?

	Yes	No	Don't know	No reply	Total
Africa	5	0	0	0	5
Asia-Pacific	15	0	0	1	16
Europe	21	0	0	0	21
Latin America	3	0	0	0	3
North America	2	0	0	0	2
Global	**46**	**0**	**0**	**1**	**47**

TABLE 282. RESPONSES TO QUESTION 13b(ii) — IF YES TO QUESTION 13a, DOES THE OFFICIAL STANDARD PROCEDURE FOR A WARNING SYSTEM REQUIRE WARNING SIGNS?

	Yes	No	Don't know	No reply	Total
Africa	5	0	0	0	5
Asia-Pacific	16	0	0	0	16
Europe	21	0	0	0	21
Latin America	3	0	0	0	3
North America	2	0	0	0	2
Global	**47**	**0**	**0**	**0**	**47**

TABLE 283. RESPONSES TO QUESTION 13b(iii) — IF YES TO QUESTION 13a, DOES THE OFFICIAL STANDARD PROCEDURE FOR A WARNING SYSTEM REQUIRE FLASHING LIGHTS?

	Yes	No	Don't know	No reply	Total
Africa	4	0	0	1	5
Asia-Pacific	10	5	0	1	16
Europe	13	6	0	2	21
Latin America	3	0	0	0	3
North America	1	1	0	0	2
Global	**31**	**12**	**0**	**4**	**47**

TABLE 284. RESPONSES TO QUESTION 13b(iv) — IF YES TO QUESTION 13a, DOES THE OFFICIAL STANDARD PROCEDURE FOR A WARNING SYSTEM REQUIRE OTHER FEATURES?

	Yes	No	Don't know	No reply	Total
Africa	0	2	0	3	5
Asia-Pacific	3	7	1	5	16
Europe	3	10	1	7	21
Latin America	2	0	0	1	3
North America	1	1	0	0	2
Global	**9**	**20**	**2**	**16**	**47**

Note: In response to other features, eight regulatory body replies were given: Operator vigilance/surveillance (3); an additional operator to monitor the area (2); audible alarm (2); survey of boundary dose rate (1).

TABLE 285. RESPONSES TO QUESTION 13c — IF YES TO QUESTION 13a, WHAT MAXIMUM DOSE RATE DOES THE OFFICIAL STANDARD PROCEDURE SPECIFY AT THE BARRIER?

	Replies	Maximum dose rate at the barrier (μSv/hour)						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	3	11.0	0.5	-	7.5	-	25	2
Asia-Pacific	15	14.3	0.5	2.5	20	25	25	1
Europe	20	40.5	0.1	7.5	15	60	300	1
Latin America	3	8.2	7	-	7.5	-	10	0
North America	2	100.0	100	-	100	-	100	0
Global	**43**	**29.8**	**0.1**	**7.5**	**10**	**25**	**300**	**4**

III.5.2.3. Requirements for the client of the radiography services

TABLE 286. RESPONSES TO QUESTION 14 — DOES THE REGULATORY BODY REQUIRE THE CLIENT (WHO IS RECEIVING THE ON-SITE RADIOGRAPHY SERVICES) TO INFORM THE LICENSEE (OF THE OPERATING NDT COMPANY) ABOUT CONDITIONS AT THE SITE THAT MIGHT AFFECT THE SAFETY OF OTHER WORKERS ON SITE?

	Yes	No	Don't know	No reply	Total
Africa	6	1	0	1	8
Asia-Pacific	7	9	0	0	16
Europe	10	17	0	0	27
Latin America	1	4	0	0	5
North America	0	3	0	0	3
Global	**24**	**34**	**0**	**1**	**59**

TABLE 287. RESPONSES TO QUESTION 14a(i) — IF YES TO QUESTION 14, DOES THIS INCLUDE THE PROVISION OF SITE PLANS?

	Yes	No	Don't know	No reply	Total
Africa	4	2	0	0	6
Asia-Pacific	4	0	2	1	7
Europe	8	1	1	0	10
Latin America	1	0	0	0	1
North America	0	0	0	0	0
Global	**17**	**3**	**3**	**1**	**24**

TABLE 288. RESPONSES TO QUESTION 14a(ii) — IF YES TO QUESTION 14, DOES THIS INCLUDE INFORMATION ABOUT OTHER WORKER ACTIVITIES, OCCURRING AT THE SAME TIME AND IN THE VICINITY OF WHERE THE RADIOGRAPHY WILL OCCUR?

	Yes	No	Don't know	No reply	Total
Africa	5	0	0	1	6
Asia-Pacific	6	0	0	1	7
Europe	10	0	0	0	10
Latin America	1	0	0	0	1
North America	0	0	0	0	0
Global	**22**	**0**	**0**	**2**	**24**

III.5.2.4. Requirements for radiation protection officers on-site

TABLE 289. RESPONSES TO QUESTION 15 — DOES THE REGULATORY BODY REQUIRE THAT THERE IS A QUALIFIED RADIATION PROTECTION OFFICER OR RADIATION PROTECTION EXPERT ON THE WORK SITE DURING ON-SITE RADIOGRAPHY?

	Yes	No	Don't know	No reply	Total
Africa	5	2	0	1	8
Asia-Pacific	9	6	0	1	16
Europe	9	18	0	0	27
Latin America	4	1	0	0	5
North America	1	2	0	0	3
Global	**28**	**29**	**0**	**2**	**59**

III.5.3. Safety of sources and exposure devices

III.5.3.1. Standards for sealed sources

TABLE 290. RESPONSES TO QUESTION 16 — DOES THE REGULATORY BODY REQUIRE THAT ANY SEALED SOURCE USED FOR INDUSTRIAL RADIOGRAPHY PURPOSES MUST MEET SPECIFIED STANDARDS?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	1	8
Asia-Pacific	11	3	2	0	16
Europe	20	5	0	2	27
Latin America	4	1	0	0	5
North America	1	1	0	1	3
Global	**43**	**10**	**2**	**4**	**59**

TABLE 291. RESPONSES TO QUESTION 16a — IF YES TO QUESTION 16, PLEASE SPECIFY THE STANDARDS

	No. of RBs providing information	Standards specified							
		a	b	c	d	e	f	g	h
Africa	4	1	1	0	0	3	0	0	0
Asia-Pacific	8	4	1	3	1	0	1	0	0
Europe	15	9	1	4	0	1	3	0	0
Latin America	3	1	0	1	0	2	0	1	0
North America	1	0	0	0	0	0	0	0	1
Global	**31**	**15**	**3**	**8**	**1**	**6**	**4**	**1**	**1**

a = ISO2919:1999 RP – Sealed radioactive sources – general requirements [3][3].

b = ISO9978:1992 RP – Sealed radioactive sources – leakage test methods [4].

c = National regulations, standards or norms.

d = ISO3999:2004 – Radiation protection – Apparatus for industrial gamma radiography – Specifications for performance, design and tests [5].

e = Unspecified international standards – ISO, IEC, IAEA, EU.

f = Current special form certificate or transport certificate.

g = IAEA TS-R-1 [6][4].

h = ANSI N432-1980, Radiological safety for the design and construction of apparatus for gamma radiography [7].

[3] While relevant at the time of the survey, this standard has now been superseded by: ISO2919:2012 Radiological Protection – Sealed radioactive sources – General requirements and classification.

[4] While relevant at the time of the survey, this standard has now been superseded by: IAEA, Regulations for the Safe Transport of Radioactive Material, 2012 Edition, IAEA Safety Standards Series No. SSR-6, IAEA, Vienna (2012).

TABLE 292. RESPONSES TO QUESTION 17 – DOES THE REGULATORY BODY REQUIRE THAT ANY EXPOSURE DEVICE USED FOR INDUSTRIAL RADIOGRAPHY PURPOSES MUST MEET SPECIFIED STANDARDS?

	Yes	No	Don't know	No reply	Total
Africa	6	0	0	2	8
Asia-Pacific	11	3	2	0	16
Europe	21	3	1	2	27
Latin America	3	2	0	0	5
North America	2	1	0	0	3
Global	**43**	**9**	**3**	**4**	**59**

TABLE 293. RESPONSES TO QUESTION 17a – IF YES TO QUESTION 17, PLEASE SPECIFY THE STANDARDS

	No. of RBs providing information	Standards specified							
		a	b	c	d	e	f	g	h
Africa	4	1	1	0	0	3	0	0	0
Asia-Pacific	8	0	0	4	2	1	1	1	0
Europe	17	0	0	3	11	3	2	0	0
Latin America	2	0	0	1	1	0	0	0	0
North America	2	0	0	1	0	0	0	0	1
Global	**33**	**1**	**1**	**9**	**14**	**7**	**3**	**1**	**1**

a = ISO2919:1999 RP – Sealed radioactive sources - general requirements [3][5].

b = ISO9978:1992 RP – Sealed radioactive sources - leakage test methods [4].

c = National regulations, standards or norms.

d = ISO3999:2004 – Radiation protection – Apparatus for industrial gamma radiography – Specifications for performance, design and tests [5].

e = Unspecified international standards – ISO, IEC, IAEA, EU.

f = Current special form certificate or transport certificate.

g = IAEA TS-R-1 [6][6].

h = ANSI N432-1980, Radiological safety for the design and construction of apparatus for gamma radiography [7].

[5] While relevant at the time of the survey, this standard has now been superseded by: ISO2919:2012 Radiological Protection – Sealed radioactive sources – General requirements and classification.

[6] While relevant at the time of the survey, this standard has now been superseded by: IAEA, Regulations for the Safe Transport of Radioactive Material, 2012 Edition, IAEA Safety Standards Series No. SSR-6, IAEA, Vienna (2012).

III.5.3.2. Requirements for inspections and maintenance — sources and exposure devices

TABLE 294. RESPONSES TO QUESTION 18 — DOES THE REGULATORY BODY REQUIRE THAT THE SOURCE AND THE EXPOSURE DEVICE ARE SUBJECT TO RIGOROUS PERIODIC INSPECTIONS/TESTS AND MAINTENANCE TO VERIFY COMPLIANCE WITH REQUIRED STANDARDS?

	Yes	No	Don't know	No reply	Total
Africa	6	1	0	1	8
Asia-Pacific	11	4	0	1	16
Europe	21	4	0	2	27
Latin America	4	1	0	0	5
North America	3	0	0	0	3
Global	**45**	**10**	**0**	**4**	**59**

TABLE 295. RESPONSES TO QUESTION 18a — IF YES TO QUESTION 18, WHAT IS THE REQUIRED FREQUENCY?

	Replies	Number of months between inspections						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	4	14.5	4	10	12	16.5	30	2
Asia-Pacific	11	10.6	3	12	12	12	12	0
Europe	15	14. 7	1	12	12	12	60	6
Latin America	3	8.3	1		12		12	1
North America	2	3.0	3		3		3	1
Global	**35**	**12.2**	**1**	**9**	**12**	**12**	**60**	**10**

Note: Four regulatory bodies stated that the frequency was variable; 2 invoked manufacturer's specifications; and 1 stated at reload.

TABLE 296. RESPONSES TO QUESTION 18b — IF YES TO QUESTION 18, ARE ACCESSORIES INCLUDED?

	Yes	No	Don't know	No reply	Total
Africa	3	0	1	2	6
Asia-Pacific	10	1	0	0	11
Europe	19	2	0	0	21
Latin America	4	0	0	0	4
North America	3	0	0	0	3
Global	**39**	**3**	**1**	**2**	**45**

TABLE 297. RESPONSES TO QUESTION 18c(i) — IF YES TO QUESTION 18, IS THE MANUFACTURER OR MANUFACTURER'S AGENT PERMITTED BY THE REGULATORY BODY TO PERFORM SUCH SERVICES?

	Yes	No	Don't know	No reply	Total
Africa	4	2	0	0	6
Asia-Pacific	10	0	0	1	11
Europe	16	1	0	4	21
Latin America	4	0	0	0	4
North America	3	0	0	0	3
Global	**37**	**3**	**0**	**5**	**45**

TABLE 298. RESPONSES TO QUESTION 18c(ii) — IF YES TO QUESTION 18, IS THE NDT COMPANY PERMITTED BY THE REGULATORY BODY TO PERFORM SUCH SERVICES?

	Yes	No	Don't know	No reply	Total
Africa	2	2	0	2	6
Asia-Pacific	8	2	0	1	11
Europe	8	7	1	5	21
Latin America	3	0	0	1	4
North America	3	0	0	0	3
Global	**24**	**11**	**1**	**9**	**45**

TABLE 299. RESPONSES TO QUESTION 18c(iii) — IF YES TO QUESTION 18, IS ANOTHER THIRD PARTY PERMITTED BY THE REGULATORY BODY TO PERFORM SUCH SERVICES?

	Yes	No	Don't know	No reply	Total
Africa	2	1	0	3	6
Asia-Pacific	5	3	0	3	11
Europe	15	3	0	3	21
Latin America	1	2	0	1	4
North America	2	0	0	1	3
Global	**25**	**9**	**0**	**11**	**45**

Note: 23 out of the 25 regulatory bodies specified that such services were permitted to be performed by companies, technical service organisations, or persons who had been approved or licensed or certified by the regulatory body or other appropriate authority. Two regulatory bodies did not provide details.

III.5.3.3. Standards for X ray equipment

TABLE 300. RESPONSES TO QUESTION 19 — DOES THE REGULATORY BODY REQUIRE THAT ANY X RAY GENERATOR USED FOR INDUSTRIAL RADIOGRAPHY PURPOSES MUST MEET SPECIFIED STANDARDS?

	Yes	No	Don't know	No reply	Total
Africa	6	0	1	1	8
Asia-Pacific	10	4	1	1	16
Europe	16	9	1	1	27
Latin America	2	2	1	0	5
North America	2	0	0	1	3
Global	**36**	**15**	**4**	**4**	**59**

TABLE 301. RESPONSES TO QUESTION 19a — IF YES TO QUESTION 19, PLEASE SPECIFY THE STANDARDS

	Replies	No reply	National Standards	International Standards
Africa	4	2	0	4
Asia-Pacific	8	2	4	4
Europe	12	4	6	8
Latin America	1	1	1	0
North America	2	0	2	0
Global	**27**	**9**	**13**	**16**

III.5.3.4. Requirements for inspection and maintenance —X ray equipment

TABLE 302. RESPONSES TO QUESTION 20 — DOES THE REGULATORY BODY REQUIRE THAT THE X RAY EQUIPMENT IS SUBJECT TO RIGOROUS PERIODIC INSPECTIONS/TESTS AND MAINTENANCE TO VERIFY COMPLIANCE WITH REQUIRED STANDARDS?

	Yes	No	Don't know	No reply	Total
Africa	6	1	0	1	8
Asia-Pacific	8	6	1	1	16
Europe	22	5	0	0	27
Latin America	3	1	1	0	5
North America	2	0	0	1	3
Global	**41**	**13**	**2**	**3**	**59**

TABLE 303. RESPONSES TO QUESTION 20a — IF YES TO QUESTION 20, WHAT IS THE REQUIRED FREQUENCY?

	Replies	Number of months between inspections						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	5	18.0	6	12	12	12	48	1
Asia-Pacific	8	10.9	3	12	12	12	12	0
Europe	14	15.9	1	12	12	12	60	8
Latin America	3	8.3	1	-	12	-	12	0
North America	2	3.0	3	-	3	-	3	0
Global	**32**	**13.5**	**1**	**12**	**12**	**12**	**60**	**9**

TABLE 304. RESPONSES TO QUESTION 20b — IF YES TO QUESTION 20, ARE ACCESSORIES INCLUDED?

	Yes	No	Don't know	No reply	Total
Africa	3	1	1	1	6
Asia-Pacific	6	0	0	2	8
Europe	20	1	0	1	22
Latin America	2	0	0	1	3
North America	2	0	0	0	2
Global	**33**	**2**	**1**	**5**	**41**

TABLE 305. RESPONSES TO QUESTION 20c(i) — IF YES TO QUESTION 20, IS THE MANUFACTURER OR MANUFACTURER'S AGENT PERMITTED BY THE REGULATORY BODY TO PERFORM SUCH SERVICES?

	Yes	No	Don't know	No reply	Total
Africa	4	0	0	2	6
Asia-Pacific	7	0	0	1	8
Europe	16	3	0	3	22
Latin America	3	0	0	0	3
North America	2	0	0	0	2
Global	**32**	**3**	**0**	**6**	**41**

TABLE 306. RESPONSES TO QUESTION 20c(ii) — IF YES TO QUESTION 20, IS THE NDT OPERATING COMPANY PERMITTED BY THE REGULATORY BODY TO PERFORM SUCH SERVICES?

	Yes	No	Don't know	No reply	Total
Africa	2	1	0	3	6
Asia-Pacific	7	0	0	1	8
Europe	11	4	1	6	22
Latin America	1	1	0	1	3
North America	2	0	0	0	2
Global	**23**	**6**	**1**	**11**	**41**

TABLE 307. RESPONSES TO QUESTION 20c(iii) — IF YES TO QUESTION 20, IS ANOTHER THIRD PARTY PERMITTED BY THE REGULATORY BODY TO PERFORM SUCH SERVICES?

	Yes	No	Don't know	No reply	Total
Africa	2	1	0	3	6
Asia-Pacific	4	1	0	3	8
Europe	16	4	0	2	22
Latin America	2	0	0	1	3
North America	1	0	0	1	2
Global	**25**	**6**	**0**	**10**	**41**

Note: 22 out of the 25 regulatory bodies specified that these third parties were companies, technical service organizations, or persons who had been approved or licensed or certified by the regulatory body or other appropriate authority. 3 regulatory bodies did not provide details.

III.5.3.5. Requirements for storage of sources

TABLE 308. RESPONSES TO QUESTION 21 — DOES THE REGULATORY BODY SPECIFY REQUIREMENTS FOR ON-SITE STORAGE OF SOURCES?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	1	8
Asia-Pacific	15	0	0	1	16
Europe	26	1	0	0	27
Latin America	5	0	0	0	5
North America	2	0	0	1	3
Global	**55**	**1**	**0**	**3**	**59**

TABLE 309. RESPONSES TO QUESTION 22 — DOES THE REGULATORY BODY REQUIRE THE LICENSEE TO CONDUCT PERIODIC DOCUMENTED CHECKS OF SOURCES TO CONFIRM THAT THEY ARE IN THEIR ASSIGNED LOCATIONS AND ARE SECURE?

	Yes	No	Don't know	No reply	Total
Africa	6	1	0	1	8
Asia-Pacific	15	1	0	0	16
Europe	25	2	0	0	27
Latin America	5	0	0	0	5
North America	2	0	0	1	3
Global	**53**	**4**	**0**	**2**	**59**

III.6. REGULATORY INSPECTIONS AND RADIATION PROTECTION OFFICERS

III.6.1. Regulatory inspections — type and frequency

TABLE 310. RESPONSES TO QUESTION 23 — DOES THE REGULATORY BODY PERFORM INSPECTIONS OF NDT OPERATING COMPANIES THAT PROVIDE ON-SITE RADIOGRAPHY SERVICES?

	Yes	No	Don't know	No reply	Total
Africa	5	2	0	1	8
Asia-Pacific	16	0	0	0	16
Europe	26	1	0	0	27
Latin America	4	1	0	0	5
North America	3	0	0	0	3
Global	**54**	**4**	**0**	**1**	**59**

TABLE 311. RESPONSES TO QUESTION 23a — IF YES TO QUESTION 23, ARE THESE INSPECTIONS TO WHERE ON-SITE RADIOGRAPHY IS ACTUALLY TAKING PLACE?

	Yes	No	Don't know	No reply	Total
Africa	4	1	0	0	5
Asia-Pacific	14	2	0	0	16
Europe	21	3	2	0	26
Latin America	4	0	0	0	4
North America	3	0	0	0	3
Global	**46**	**6**	**2**	**0**	**54**

TABLE 312. RESPONSES TO QUESTION 23b — IF YES TO QUESTION 23, ARE THESE INSPECTIONS ANNOUNCED, UNANNOUNCED, OR EITHER?

	Announced only	Unannounced only	Either announced or unannounced	No reply	Total
Africa	1	0	4	0	5
Asia-Pacific	4	1	10	1	16
Europe	7	0	19	0	26
Latin America	1	0	3	0	4
North America	1	0	2	0	3
Global	**14**	**1**	**38**	**1**	**54**

TABLE 313. RESPONSES TO QUESTION 23c — IF YES TO QUESTION 23, HOW OFTEN IS A GIVEN LICENSEE INSPECTED BY THE REGULATORY BODY?

	Replies	Number of RB inspections to a licensee per year						No reply
		Mean	Min	Q1	Median	Q3	Max	
Africa	4	1.4	0.4	0.9	1	1.5	3	1
Asia-Pacific	14	1.1	0.2	1	1	1.2	2.5	2
Europe	21	0.8	0.1	0.5	1	1	2.5	5
Latin America	4	1.3	1	1	1	1.3	2	0
North America	3	0.8	0.3	-	1	-	1	0
Global	**46**	**1.0**	**0.1**	**0.5**	**1**	**1**	**3**	**8**

III.6.2. Items addressed during regulatory body inspections

TABLE 314. RESPONSES TO QUESTIONS 23d(i-iii) — IF YES TO QUESTION 23, ARE THE WEARING OF PASSIVE DOSIMETERS, WEARING OF ACTIVE DOSIMETERS, AND THE USE OF SURVEY METERS ADDRESSED DURING THE INSPECTIONS?

	Wearing of passive individual dosimeters			Wearing and use of active individual dosimeters			Use of survey meters		
	Yes	No	No reply	Yes	No	No reply	Yes	No	No reply
Africa	4	1	0	4	0	1	5	0	0
Asia-Pacific	15	0	1	11	4	1	14	1	1
Europe	25	0	1	25	0	1	24	1	1
Latin America	4	0	0	3	1	0	4	0	0
North America	3	0	0	3	0	0	3	0	0
Global	**51**	**1**	**2**	**46**	**5**	**3**	**50**	**2**	**2**

TABLE 315. RESPONSES TO QUESTIONS 23d(iv-vi) — IF YES TO QUESTION 23, ARE THE USE OF COLLIMATORS, USE OF WARNING SYSTEMS, AND THE DOSE RATE AT THE BOUNDARY OF WARNING SYSTEMS ADDRESSED DURING THE INSPECTIONS?

	Use of collimators			**Use of warning systems to prevent entry at the work site**			**Dose rate at the boundary of warning system**		
	Yes	**No**	**No reply**	**Yes**	**No**	**No reply**	**Yes**	**No**	**No reply**
Africa	3	1	1	5	0	0	5	0	0
Asia-Pacific	14	1	1	15	0	1	13	2	1
Europe	21	3	2	24	1	1	22	3	1
Latin America	4	0	0	4	0	0	4	0	0
North America	2	1	0	3	0	0	3	0	0
Global	**44**	**6**	**4**	**51**	**1**	**2**	**47**	**5**	**2**

TABLE 316. RESPONSES TO QUESTIONS 23d(vii-ix) — IF YES TO QUESTION 23, ARE THE USE OF ALARM SYSTEMS, TRAINING AND QUALIFICATIONS OF RADIOGRAPHERS, AND OPERATOR KNOWLEDGE OF PROCEDURES ADDRESSED DURING THE INSPECTIONS?

	Use of alarm systems			**Training and qualifications of radiographers**			**Operator knowledge of procedures**		
	Yes	**No**	**No reply**	**Yes**	**No**	**No reply**	**Yes**	**No**	**No reply**
Africa	5	0	0	5	0	0	5	0	0
Asia-Pacific	14	0	2	15	0	1	11	1	4
Europe	23	2	1	25	0	1	24	1	1
Latin America	4	0	0	4	0	0	4	0	0
North America	3	0	0	3	0	0	3	0	0
Global	**49**	**2**	**3**	**52**	**0**	**2**	**47**	**2**	**5**

TABLE 317. RESPONSES TO QUESTIONS 23d(x-xii) — IF YES TO QUESTION 23, ARE PRE-OPERATION EQUIPMENT CHECKS, EQUIPMENT CONDITION, AND EMERGENCY PREPAREDNESS ADDRESSED DURING THE INSPECTIONS?

	Pre-operation equipment checks			**Equipment conditions**			**Emergency preparedness**		
	Yes	**No**	**No reply**	**Yes**	**No**	**No reply**	**Yes**	**No**	**No reply**
Africa	5	0	0	5	0	0	5	0	0
Asia-Pacific	11	1	4	12	1	3	11	1	4
Europe	19	6	1	25	0	1	24	1	1
Latin America	4	0	0	4	0	0	4	0	0
North America	3	0	0	3	0	0	3	0	0
Global	**42**	**7**	**5**	**49**	**1**	**4**	**47**	**2**	**5**

In addition to the data presented in Tables 314 — 317, 11 regulatory bodies specified that other items addressed during inspections, included: Compliance with transport regulations (4); documentation and source movement log (4); physical security arrangements (3); completeness of procedures (3); site storage (2); licensing (2); use of additional radiation protection features (1); safety management in the NDT Company (1); minimum number of operators on site (1).

III.6.3. Common shortcomings identified during regulatory body inspections

TABLE 318. ALL REGIONS' RESPONSES TO QUESTION 23e — IF YES TO QUESTION 23, RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN REGULATORY BODY INSPECTIONS

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	5	1	2	3	3	40	14	**6**
No proper wearing and use of active individual dosimeters	3	3	3	1	1	43	11	**7**
No proper use of survey meters	9	5	4	2	4	30	24	**1**
No proper use of collimators	1	2	0	3	4	44	10	**12**
No proper warning system to prevent entry to the work site	3	5	9	3	4	30	24	**2**
Dose rate at the boundary of the work site not within limits set	4	3	3	6	1	37	17	**5**
No proper use of alarm systems	1	9	4	2	1	37	17	**4**
No proper training and qualifications of radiographers	1	2	5	2	3	41	13	**9**
Poor operator knowledge of procedures	3	2	1	3	5	40	14	**8**
No pre-operation specific equipment checks being performed	1	1	4	3	5	40	14	**11**
Poor equipment condition	3	2	0	4	2	43	11	**10**
Poor emergency preparedness	5	4	3	4	4	34	20	**3**
Other	3	1	0	2	0	48	6	**13**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 319. AFRICAN REGION'S RESPONSES TO QUESTION 23e — IF YES TO QUESTION 23, RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN REGULATORY BODY INSPECTIONS

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	1	0	0	1	0	3	2	**1**
No proper wearing and use of active individual dosimeters	0	0	0	0	0	5	0	**10**
No proper use of survey meters	1	0	0	0	1	3	2	**2**
No proper use of collimators	0	0	0	0	0	5	0	**10**
No proper warning system to prevent entry to the work site	0	0	1	0	0	4	1	**8**
Dose rate at the boundary of the work site not within limits set	0	1	0	0	0	4	1	**6**
No proper use of alarm systems	0	0	0	0	0	5	0	**10**
No proper training and qualifications of radiographers	0	0	1	1	1	2	3	**2**
Poor operator knowledge of procedures	1	0	0	0	1	3	2	**2**
No pre-operation specific equipment checks being performed	0	0	1	0	0	4	1	**8**
Poor equipment condition	0	1	0	0	0	4	1	**6**
Poor emergency preparedness	0	1	0	1	0	3	2	**2**
Other	0	0	0	0	0	5	0	**10**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 320. ASIA PACIFIC REGION'S RESPONSES TO QUESTION 23e — IF YES TO QUESTION 23, RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN REGULATORY BODY INSPECTIONS

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	1	1	0	0	1	13	3	**9**
No proper wearing and use of active individual dosimeters	0	2	1	1	0	12	4	**7**
No proper use of survey meters	5	1	2	0	1	7	9	**1**
No proper use of collimators	0	0	0	1	3	12	4	**12**
No proper warning system to prevent entry to the work site	2	1	1	1	2	9	7	**2**
Dose rate at the boundary of the work site not within limits set	0	1	2	2	0	11	5	**5**
No proper use of alarm systems	0	3	3	2	0	8	8	**4**
No proper training and qualifications of radiographers	1	0	0	0	0	15	1	**9**
Poor operator knowledge of procedures	0	1	0	0	1	14	2	**8**
No pre-operation specific equipment checks being performed	0	0	2	1	3	10	6	**11**
Poor equipment condition	1	1	0	2	0	12	4	**10**
Poor emergency preparedness	2	1	1	1	1	10	6	**3**
Other	1	0	0	1	0	14	2	**13**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 321. EUROPEAN REGION'S RESPONSES TO QUESTION 23e — IF YES TO QUESTION 23, RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN REGULATORY BODY INSPECTIONS

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	3	0	1	2	1	19	7	**6**
No proper wearing and use of active individual dosimeters	1	0	2	0	0	23	3	**12**
No proper use of survey meters	2	2	1	2	2	17	9	**5**
No proper use of collimators	1	1	0	2	1	21	5	**9**
No proper warning system to prevent entry to the work site	1	3	6	2	1	13	13	**1**
Dose rate at the boundary of the work site not within limits set	3	1	1	3	1	17	9	**3**
No proper use of alarm systems	1	5	1	0	1	18	8	**3**
No proper training and qualifications of radiographers	0	2	4	1	1	18	8	**6**
Poor operator knowledge of procedures	1	1	1	1	3	19	7	**8**
No pre-operation specific equipment checks being performed	1	1	0	1	1	22	4	**11**
Poor equipment condition	1	0	0	2	2	21	5	**12**
Poor emergency preparedness	3	2	1	2	3	15	11	**2**
Other	2	1	0	0	0	23	3	**9**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 322. LATIN AMERICAN REGION'S RESPONSES TO QUESTION 23e — IF YES TO QUESTION 23, RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN REGULATORY BODY INSPECTIONS

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	0	0	0	0	1	3	1	**10**
No proper wearing and use of active individual dosimeters	1	1	0	0	0	2	2	**2**
No proper use of survey meters	1	1	1	0	0	1	3	**1**
No proper use of collimators	0	0	0	0	0	4	0	**12**
No proper warning system to prevent entry to the work site	0	0	1	0	1	2	2	**4**
Dose rate at the boundary of the work site not within limits set	0	0	0	1	0	3	1	**7**
No proper use of alarm systems	0	1	0	0	0	3	1	**4**
No proper training and qualifications of radiographers	0	0	0	0	1	3	1	**10**
Poor operator knowledge of procedures	1	0	0	0	0	3	1	**3**
No pre-operation specific equipment checks being performed	0	0	0	1	0	3	1	**7**
Poor equipment condition	0	0	0	0	0	4	0	**12**
Poor emergency preparedness	0	0	1	0	0	3	1	**6**
Other	0	0	0	1	0	3	1	**7**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

TABLE 323. NORTH AMERICAN REGION'S RESPONSES TO QUESTION 23e — IF YES TO QUESTION 23, RANK THE COMMON SHORTCOMINGS, IN ORDER OF THE FREQUENCY IN WHICH THEY ARE OBSERVED IN REGULATORY BODY INSPECTIONS

Shortcoming	Number of times ranked as:					No. of times not ranked	No. of times ranked 1 to 5	Overall[1] ranking
	1	2	3	4	5			
No proper wearing of passive individual dosimeters	0	0	1	0	0	2	1	**9**
No proper wearing and use of active individual dosimeters	1	0	0	0	1	1	2	**1**
No proper use of survey meters	0	1	0	0	0	2	1	**4**
No proper use of collimators	0	1	0	0	0	2	1	**4**
No proper warning system to prevent entry to the work site	0	1	0	0	0	2	1	**4**
Dose rate at the boundary of the work site not within limits set	1	0	0	0	0	2	1	**2**
No proper use of alarm systems	0	0	0	0	0	3	0	**10**
No proper training and qualifications of radiographers	0	0	0	0	0	3	0	**10**
Poor operator knowledge of procedures	0	0	0	2	0	1	2	**4**
No pre-operation specific equipment checks being performed	0	0	1	0	1	1	2	**4**
Poor equipment condition	1	0	0	0	0	2	1	**2**
Poor emergency preparedness	0	0	0	0	0	3	0	**10**
Other	0	0	0	0	0	3	0	**10**

[1] The overall ranking was determined by applying weightings of 5, 4, 3, 2, 1 to the number of times a shortcoming was ranked 1st, 2nd, 3rd, 4th, and 5th, respectively. The shortcoming with the highest total was then assigned the highest overall ranking, and so on.

III.6.4. Requirements for radiation protection officers

TABLE 324. RESPONSES TO QUESTION 24 — DOES THE REGULATORY BODY REQUIRE THAT A LICENSEE (NDT OPERATING COMPANY) EMPLOYS A RADIATION PROTECTION OFFICER OR RADIATION PROTECTION EXPERT?

	Yes	No	Don't know	No reply	Total
Africa	6	0	0	2	**8**
Asia-Pacific	14	2	0	0	**16**
Europe	24	3	0	0	**27**
Latin America	5	0	0	0	**5**
North America	3	0	0	0	**3**
Global	**52**	**5**	**0**	**2**	**59**

TABLE 325. RESPONSES TO QUESTION 24a — IF YES TO QUESTION 24, DOES THE REGULATORY BODY REQUIRE THAT THE RPO OR RPE REPORTS DIRECTLY TO THE MANAGING DIRECTOR OF THE COMPANY?

	Yes	No	Don't know	No reply	Total
Africa	5	0	1	0	**6**
Asia-Pacific	12	1	0	1	**14**
Europe	17	6	1	0	**24**
Latin America	5	0	0	0	**5**
North America	1	2	0	0	**3**
Global	**40**	**9**	**2**	**1**	**52**

III.7. EMERGENCY PREPAREDNESS AND RESPONSE

TABLE 326. RESPONSES TO QUESTION 25 — DOES THE REGULATORY BODY REQUIRE THAT A LICENSEE (NDT OPERATING COMPANY) HAS AN EMERGENCY PLAN?

	Yes	No	Don't know	No reply	Total
Africa	7	0	0	1	**8**
Asia-Pacific	15	1	0	0	**16**
Europe	27	0	0	0	**27**
Latin America	5	0	0	0	**5**
North America	3	0	0	0	**3**
Global	**57**	**1**	**0**	**1**	**59**

TABLE 327. RESPONSES TO QUESTION 25a — IF YES TO QUESTION 25, DOES THE REGULATORY BODY REQUIRE THAT THE EMERGENCY PLAN SPECIFIES REQUIREMENTS FOR TRAINING AND EXERCISES?

	Yes	No	Don't know	No reply	Total
Africa	6	1	0	0	7
Asia-Pacific	13	2	0	0	15
Europe	20	7	0	0	27
Latin America	2	3	0	0	5
North America	2	1	0	0	3
Global	**43**	**14**	**0**	**0**	**57**

TABLE 328. RESPONSES TO QUESTION 25b — IF YES TO QUESTION 25, DOES THE REGULATORY BODY APPROVE THE LICENSEE'S EMERGENCY PLAN?

	Yes	No	Don't know	No reply	Total
Africa	6	1	0	0	**7**
Asia-Pacific	12	3	0	0	**15**
Europe	19	7	0	1	**27**
Latin America	4	0	0	1	**5**
North America	2	1	0	0	**3**
Global	**43**	**12**	**0**	**2**	**57**

TABLE 329. RESPONSES TO QUESTION 26 — DOES THE REGULATORY BODY REQUIRE THAT LICENSEES MUST HAVE EMERGENCY EQUIPMENT?

	Yes	No	Don't know	No reply	Total
Africa	5	2	0	1	**8**
Asia-Pacific	14	2	0	0	**16**
Europe	18	7	1	1	**27**
Latin America	5	0	0	0	**5**
North America	1	2	0	0	**3**
Global	**43**	**13**	**1**	**2**	**59**

TABLE 330. RESPONSES TO QUESTION 27 — DOES THE REGULATORY BODY HAVE RESOURCES TO ASSIST LICENSEES IN RECOVERING FROM EMERGENCIES?

	Yes	No	Don't know	No reply	Total
Africa	1	5	1	1	**8**
Asia-Pacific	14	2	0	0	**16**
Europe	16	7	3	1	**27**
Latin America	3	1	1	0	**5**
North America	1	2	0	0	**3**
Global	**35**	**17**	**5**	**2**	**59**

TABLE 331. RESPONSES TO QUESTION 28 — DOES THE REGULATORY BODY CHECK THE EMERGENCY PLAN AND THE LIST OF EMERGENCY EQUIPMENT FOR RADIOGRAPHIC WORK DURING THE PERIODIC INSPECTION OR AT LICENCE RENEWAL FOR THE NDT OPERATING COMPANY?

	Yes	No	Don't know	No reply	Total
Africa	6	1	0	1	**8**
Asia-Pacific	14	2	0	0	**16**
Europe	24	2	0	1	**27**
Latin America	5	0	0	0	**5**
North America	3	0	0	0	**3**
Global	**52**	**5**	**0**	**2**	**59**

III.8. INDIVIDUAL MONITORING

TABLE 332. RESPONSES TO QUESTION 29 — DOES THE REGULATORY BODY HAVE DIRECT ACCESS TO A NATIONAL OR STATE DATABASE OF INDIVIDUAL DOSES FOR INDUSTRIAL RADIOGRAPHERS AND OTHER INVOLVED IN NDT?

	Yes	No	Don't know	No reply	Total
Africa	2	5	0	1	**8**
Asia-Pacific	8	6	1	1	**16**
Europe	20	6	0	1	**27**
Latin America	2	3	0	0	**5**
North America	2	1	0	0	**3**
Global	**34**	**21**	**1**	**3**	**59**

TABLE 333. REPORTED NUMBERS AND DOSES OF INDUSTRIAL RADIOGRAPHERS WITH INDIVIDUAL DOSIMETRY IN 2009

	Industrial radiographers (2009)			
	No. of replies	No. monitored	Mean dose[1] (mSv)	Max dose[2] (mSv)
Africa	2	193	3.0	5.2
Asia-Pacific	8	9025	2.4	98
Europe	20	4575	1.5	158
Latin America	2	728	4.9	87
North America	1	3116	5.5	44
Global	**33**	**17637**	**2.9**	**158**

[1] Mean dose is the sum of each country mean dose × the number monitored in that country, divided by the total number of individuals monitored; by region and globally.
[2] Max dose is the highest individual dose reported, within that region or globally respectively.

TABLE 334. REPORTED NUMBERS AND DOSES OF OTHER NDT WORKERS WITH INDIVIDUAL DOSIMETRY IN 2009

	Other NDT workers (2009)			
	No. of replies	No. monitored	Mean dose[1] (mSv)	Max dose[2] (mSv)
Africa	1	47	3.4	4.5
Asia-Pacific	3	3354	6.0	26.3
Europe	6	1189	8.4	91
Latin America	0	-	-	-
North America	0	-	-	-
Global	**10**	**4590**	**0.6**	**91**

[1] Mean dose is the sum of each country mean dose × the number monitored in that country, divided by the total number of individuals monitored; by region and globally.
[2] Max dose is the highest individual dose reported, within that region or globally respectively.

TABLE 335. STATISTICS FOR COUNTRY AVERAGES OF INDIVIDUAL DOSES IN 2009 — INDUSTRIAL RADIOGRAPHERS

	Replies	Country-average effective dose (mSv)						
		Mean	SD	Min	Q1	Median	Q3	Max
Africa	2	2.5	0.9	1.9	-	2.5	-	3.1
Asia-Pacific	8	2.5	2.1	0.5	1.1	2.1	3.3	6.7
Europe	20	1.8	2.5	0.0	0.3	1.3	1.9	10.0
Latin America	2	3.1	2.8	1.2	-	3.1	-	5.1
North America	1	5.5	-	-	-	5.5	-	-
Global	**33**	**2.2**	**2.3**	**0.0**	**0.8**	**1.6**	**2.4**	**10.0**

TABLE 336. STATISTICS FOR COUNTRY AVERAGES OF INDIVIDUAL DOSES IN 2009 — OTHER NDT WORKERS

	Replies	Country-average effective dose (mSv)						
		Mean	SD	Min	Q1	Median	Q3	Max
Africa	1	3.2	-	-	-	3.2	-	-
Asia-Pacific	3	2.0	1.5	0.3	-	2.3	-	3.3
Europe	6	0.5	0.5	0.0	0.1	0.3	0.9	1.0
Latin America	0	-	-	-	-	-	-	-
North America	0	-	-	-	-	-	-	-
Global	**10**	**1.2**	**1.3**	**0.0**	**0.3**	**0.7**	**2.0**	**3.3**

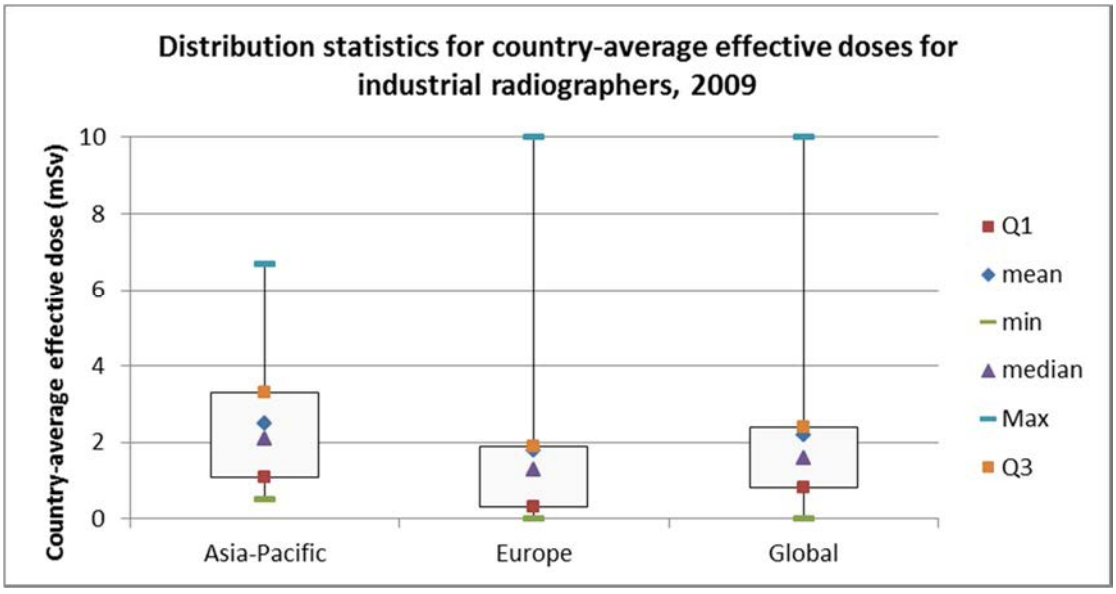

FIG. 27. Results from Table 335 giving the mean, median, minimum, maximum and first and third quartiles of the distribution of country–average annual doses for industrial radiographers in 2009.

TABLE 337. NUMBERS OF MONITORED INDUSTRIAL RADIOGRAPHERS WHOSE ANNUAL DOSES (D) IN 2009 WERE IN THE GIVEN DOSE BANDS

	Number of monitored industrial radiographers whose annual dose in 2009, D, was in the dose bands:						
	Annual effective dose bands (mSv)						
	D<mdl	**mdl≤D<1**	**1≤D<5**	**5≤D<10**	**10≤D<20**	**20≤D<50**	**D≥50**
Africa	0	1	190	2	0	0	0
Asia-Pacific	3063	2603	1437	449	285	147	41
Europe	1811	1118	1414	91	23	9	4
Latin America	0	114	409	118	61	24	2
North America	429	768	858	549	397	115	0
Global	**5303**	**4604**	**4308**	**1209**	**766**	**295**	**47**

Note: mdl = minimum detection limit of the personal dosimetry system.

TABLE 338. PERCENTAGES OF MONITORED INDUSTRIAL RADIOGRAPHERS WHOSE ANNUAL DOSES (D) IN 2009 WERE IN THE GIVEN DOSE BANDS

	Percentage of monitored industrial radiographers whose annual dose in 2009, D, was in the dose bands:						
	Annual effective dose bands (mSv)						
	D<mdl	**mdl≤D<1**	**1≤D<5**	**5≤D<10**	**10≤D<20**	**20≤D<50**	**D≥50**
Africa	0	1	98	1	0	0	0
Asia-Pacific	38	32	18	6	3	2	1
Europe	41	25	32	2	0	0	0
Latin America	0	16	56	16	8	3	0
North America	14	25	28	18	12	4	0
Global	**32**	**28**	**26**	**7**	**5**	**2**	**0**

Note: mdl = minimum detection limit of the personal dosimetry system.

TABLE 339. NUMBERS OF MONITORED 'OTHER NDT WORKERS' WHOSE ANNUAL DOSES (D) IN 2009 WERE IN THE GIVEN DOSE BANDS

	Number of monitored 'other NDT workers' whose annual dose in 2009, D, was in the dose bands:						
	Annual effective dose bands (mSv)						
	D<mdl	**mdl≤D<1**	**1≤D<5**	**5≤D<10**	**10≤D<20**	**20≤D<50**	**D≥50**
Africa	0	0	47	0	0	0	0
Asia-Pacific	1732	1163	415	36	6	2	0
Europe	315	26	646	0	1	0	1
Latin America	-	-	-	-	-	-	-
North America	-	-	-	-	-	-	-
Global	**2047**	**1189**	**1108**	**36**	**7**	**2**	**1**

Note: mdl = minimum detection limit of the personal dosimetry system.

TABLE 340. PERCENTAGES OF MONITORED 'OTHER NDT WORKERS' WHOSE ANNUAL DOSES (D) IN 2009 WERE IN THE GIVEN DOSE BANDS

	Percentage of monitored 'other NDT workers' whose annual dose in 2009, D, was in the dose bands:						
	Annual effective dose bands (mSv)						
	D<mdl	**mdl≤D<1**	**1≤D<5**	**5≤D<10**	**10≤D<20**	**20≤D<50**	**D≥50**
Africa	0	0	100	0	0	0	0
Asia-Pacific	52	35	12	1	0	0	0
Europe	32	3	65	0	0	0	0
Latin America	-	-	-	-	-	-	-
North America	-	-	-	-	-	-	-
Global	**47**	**27**	**25**	**1**	**0**	**0**	**0**

Note: mdl = minimum detection limit of the personal dosimetry system.

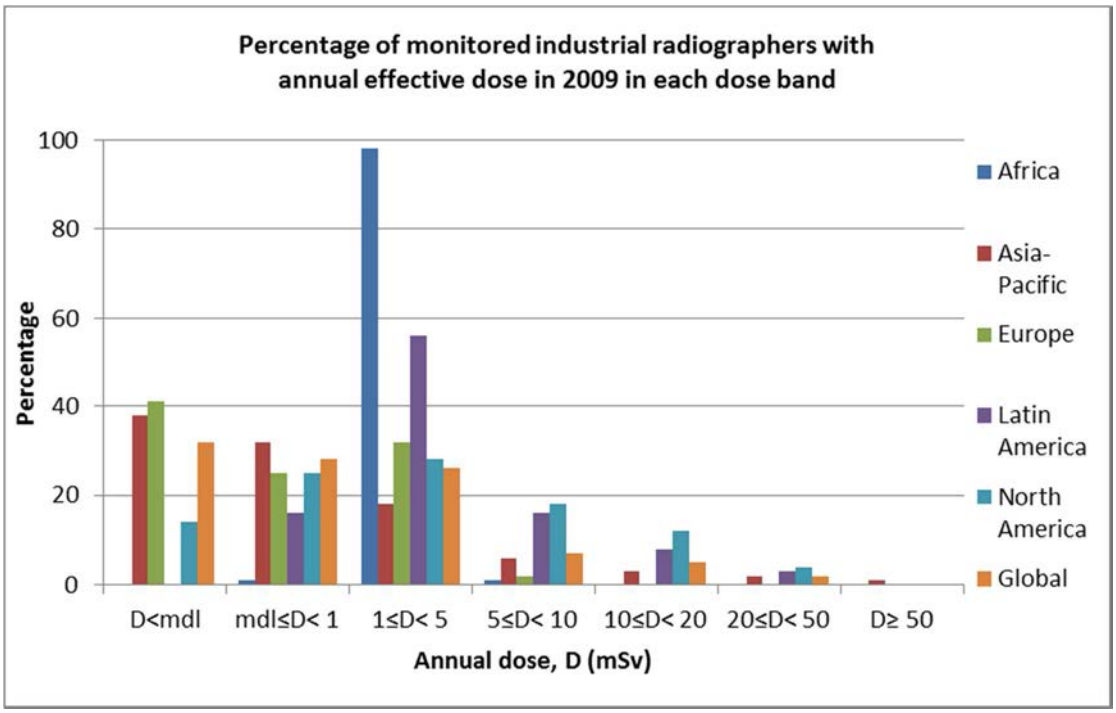

FIG. 28. Results from Table 338 giving percentages of monitored industrial radiographers whose annual effective doses in 2009 were in the given dose bands.

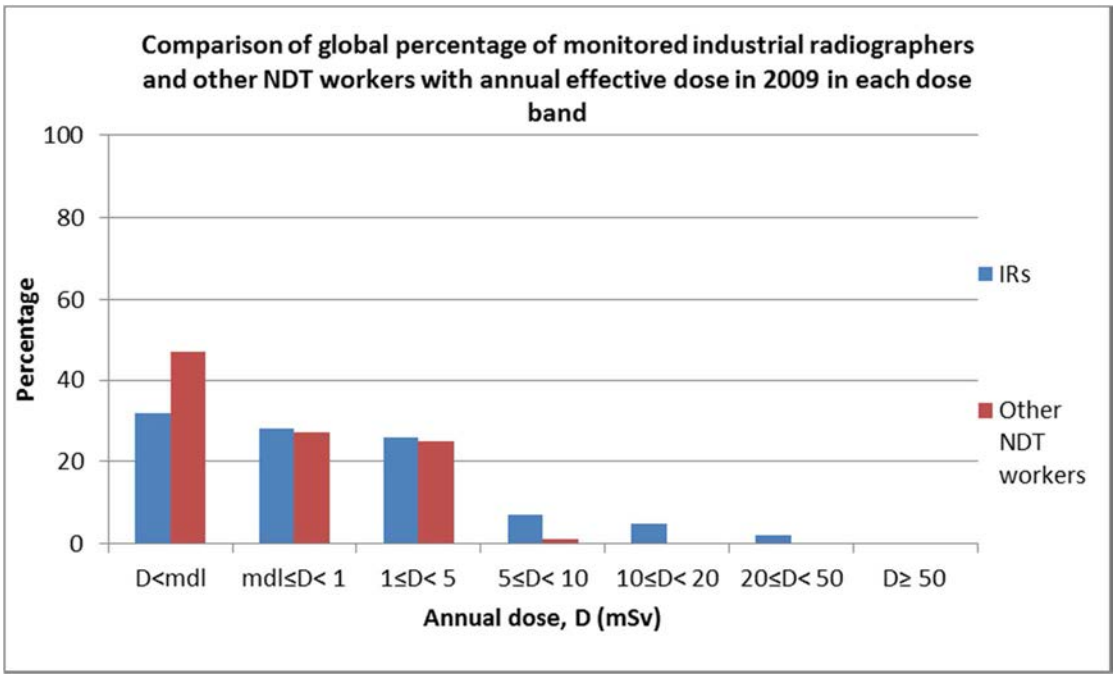

FIG. 29. Results from Tables 338 & 340 comparing the percentages of monitored industrial radiographers and other NDT workers whose annual effective doses in 2009 were in the given dose bands.

TABLE 341. NUMBER OF MONITORED INDUSTRIAL RADIOGRAPHERS WHOSE MAXIMUM MONTHLY DOSE (D_m) IN 2009 WAS IN THE GIVEN DOSE BANDS

	Number of industrial radiographers whose maximum monthly dose, D_m, was in the dose bands:						
	Dose bands of maximum effective dose in a month, D_m (mSv)						
	$1<D_m$	**$1\leq D_m<2.5$**	**$2.5\leq D_m<5$**	**$5\leq D_m<10$**	**$10\leq D_m<20$**	**$20\leq D_m<50$**	**$D_m\geq 50$**
Africa	150	41	1	1	0	0	0
Asia-Pacific	6241	239	129	89	52	10	0
Europe	1391	51	15	4	0	1	1
Latin America	419	187	93	19	2	6	2
North America	-	-	-	-	-	-	-
Global	**8201**	**518**	**238**	**113**	**54**	**17**	**3**

TABLE 342. PERCENTAGE OF MONITORED INDUSTRIAL RADIOGRAPHERS WHOSE MAXIMUM MONTHLY DOSE (D_m) IN 2009 WAS IN THE GIVEN DOSE BANDS

	Percentage of industrial radiographers whose maximum monthly dose, D_m, was in the dose bands:						
	Dose bands of maximum effective dose in a month, D_m (mSv)						
	$1<D_m$	**$1\leq D_m<2.5$**	**$2.5\leq D_m<5$**	**$5\leq D_m<10$**	**$10\leq D_m<20$**	**$20\leq D_m<50$**	**$D_m\geq 50$**
Africa	78	21	1	1	0	0	0
Asia-Pacific	92	4	2	1	1	0	0
Europe	95	3	1	0	0	0	0
Latin America	58	26	13	3	0	1	0
North America	-	-	-	-	-	-	-
Global	**90**	**6**	**3**	**1**	**1**	**0**	**0**

TABLE 343. NUMBER OF MONITORED OTHER NDT WORKERS WHOSE MAXIMUM MONTHLY DOSE (D_m) IN 2009 WAS IN THE GIVEN DOSE BANDS

	Number of 'other NDT workers' whose maximum monthly dose, D_m, was in the dose bands:						
	Dose bands of maximum effective dose in a month, D_m (mSv)						
	$1<D_m$	**$1\leq D_m<2.5$**	**$2.5\leq D_m<5$**	**$5\leq D_m<10$**	**$10\leq D_m<20$**	**$20\leq D_m<50$**	**$D_m\geq 50$**
Africa	31	16	0	0	0	0	0
Asia-Pacific	3419	34	8	5	1	0	0
Europe	122	5	0	0	1	0	0
Latin America	-	-	-	-	-	-	-
North America	-	-	-	-	-	-	-
Global	**3572**	**55**	**8**	**5**	**2**	**0**	**0**

TABLE 344. PERCENTAGE OF MONITORED OTHER NDT WORKERS WHOSE MAXIMUM MONTHLY DOSE (D_m) IN 2009 WAS IN THE GIVEN DOSE BANDS

	Percentage of 'other NDT workers' whose maximum monthly dose, D_m, was in the dose bands:						
	Dose bands of maximum effective dose in a month, D_m (mSv)						
	$1<D_m$	**$1\leq D_m<2.5$**	**$2.5\leq D_m<5$**	**$5\leq D_m<10$**	**$10\leq D_m<20$**	**$20\leq D_m<50$**	**$D_m\geq 50$**
Africa	66	34	0	0	0	0	0
Asia-Pacific	99	1	0	0	0	0	0
Europe	95	4	0	0	1	0	0
Latin America	-	-	-	-	-	-	-
North America	-	-	-	-	-	-	-
Global	**98**	**2**	**0**	**0**	**0**	**0**	**0**

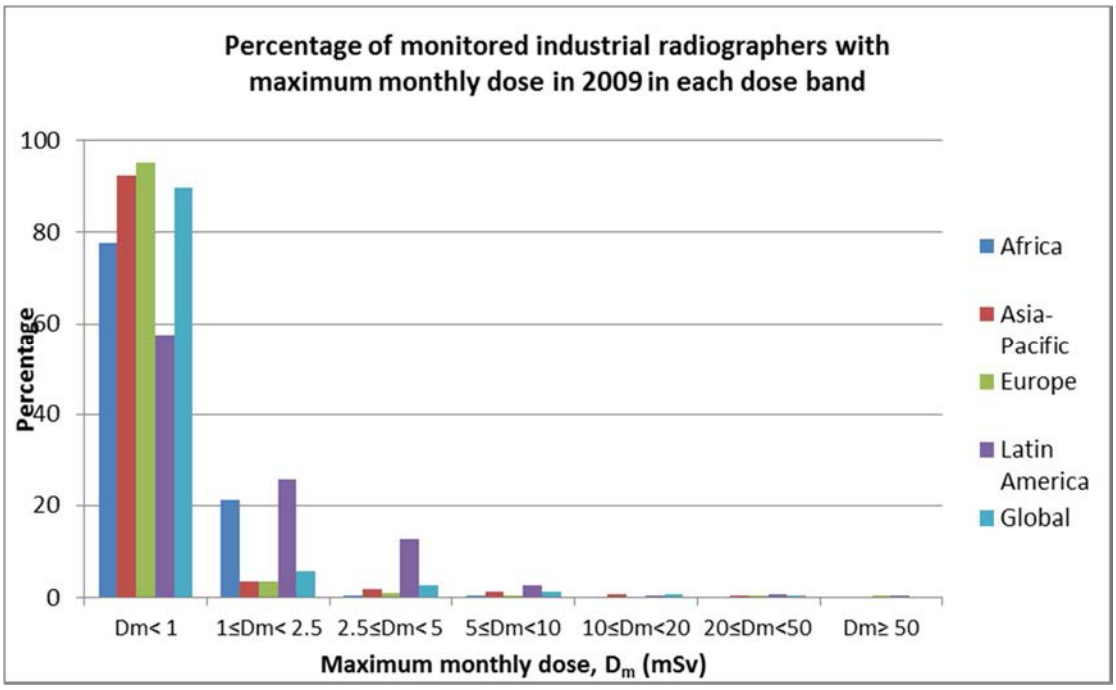

FIG. 30. Results from Table 342 giving percentage of monitored industrial radiographers whose maximum monthly dose was in given dose bands in 2009, by region and globally.

TABLE 345. RESPONSES TO QUESTION 29e — IF YES TO QUESTION 29, DO THE ABOVE GIVEN DOSE RECORDS INCLUDE DOSES RECEIVED FROM PERFORMING INDUSTRIAL RADIOGRAPHY ON-SITE AT NUCLEAR POWER PLANTS?

	Yes	No	Don't know	No reply	Total
Africa	0	2	0	0	**2**
Asia-Pacific	2	5	0	1	**8**
Europe	6	13	1	0	**20**
Latin America	1	1	0	0	**2**
North America	0	1	0	1	**2**
Global	**9**	**22**	**1**	**2**	**34**

TABLE 346. RESPONSES TO QUESTION 29f — IF YES TO QUESTION 29, DOES THE REGULATORY BODY PERFORM TREND ANALYSES (OVER, FOR EXAMPLE, 5 YEARS OR MORE) OF OCCUPATIONAL DOSES IN INDUSTRIAL RADIOGRAPHY, IN PARTICULAR FOR THE MOST EXPOSED WORKERS, AND CORRELATE THESE WITH INCIDENTS?

	Yes	No	Don't know	No reply	Total
Africa	1	1	0	0	**2**
Asia-Pacific	3	1	3	1	**8**
Europe	11	6	1	2	**20**
Latin America	1	1	0	0	**2**
North America	1	0	0	1	**2**
Global	**17**	**9**	**4**	**4**	**34**

TABLE 347. RESPONSES TO QUESTION 29g — IF YES TO QUESTION 29f, ARE THE RESULTS USED BY THE REGULATORY BODY, IN CONJUNCTION WITH THE NDT INDUSTRY, TO INITIATE MEASURES TO REDUCE THE LIKELIHOOD OF SUCH INCIDENTS RECURRING?

	Yes	No	Don't know	No reply	Total
Africa	1	0	0	0	1
Asia-Pacific	3	0	0	0	3
Europe	11	0	0	0	11
Latin America	1	0	0	0	1
North America	1	0	0	0	1
Global	**17**	**0**	**0**	**0**	**17**

APPENDIX IV. THE QUESTIONNAIRES (ENGLISH VERSIONS) USED IN THE SURVEY

IV.1. QUESTIONNAIRE DISTRIBUTED TO INDIVIDUAL RADIOGRAPHERS

International Atomic Energy Agency

Information System on Occupational Exposure in Medicine, Industry and Research (ISEMIR)

Questionnaire on Occupational Exposure in Industrial Radiography addressed to Operators

The questionnaire should be able to be completed in less than 10 minutes. It has been developed by the Working Group on Industrial Radiography (WGIR) of ISEMIR. The purpose of this survey is to provide an overview of occupational radiation protection in this area of industry where there still is a potential for workers to be exposed to higher levels of radiation as well as the risk of accidents.

The results of the survey will be sent to all participants and made available anonymously on the Networks of Occupational Radiation Protection website at IAEA. The results of the survey will allow IAEA to address recommendations to harmonise and improve radiation protection of workers in industrial radiography.

The completed questionnaire needs to be sent to the IAEA, by email to John.Le.heron@iaea.org or by mail to John Le Heron, Radiation Safety and Monitoring Section (RSM), Division of Radiation, Transport and Waste Safety (NSRW), INTERNATIONAL ATOMIC ENERGY AGENCY, Wagramer Strasse 5, P.O.Box 100, A-1400 Vienna, Austria.

1. Was radiation protection training included in your NDT–training on Radiographic Testing? *Please answer for all levels that are applicable to you.*

Level 1: Yes: ☐ No: ☐ Do not know: ☐

Level 2: Yes: ☐ No: ☐ Do not know: ☐

Level 3: Yes: ☐ No: ☐ Do not know: ☐

2. Did you receive separate training on radiation protection, either in addition to or instead of any radiation protection training in your NDT–training?

Yes: ☐ No: ☐ Do not know: ☐

2a. If yes to question 2, do you have a formal radiation protection qualification or certification?

Yes: ☐ No: ☐ Do not know: ☐

3. If you have had radiation protection training, were procedures for emergencies included in the training?

Yes: ☐ No: ☐ Do not know: ☐

3a. If yes to question 3, did the training include practical exercises for creating a safe situation until the source is able to be recovered?

Yes: ☐ No: ☐ Do not know: ☐

3b. If yes to question 3, did the training include practical exercises for source recovery?

Yes: ☐ No: ☐ Do not know: ☐

3c. Are you allowed to perform a source recovery on your own without first contacting a specialized source recovery person?

Yes: ☐ No: ☐ Do not know: ☐

4. Do you feel sufficiently well qualified and trained to be able to work safely and reliably?

Yes: ☐ No: ☐ Do not know: ☐

4a. Do you feel you are well prepared for an emergency situation?

Yes: ☐ No: ☐ Do not know: ☐

5a. When on-site radiography is being performed, is there a qualified radiation safety expert, e.g. one of the radiographers or a Radiation Protection Officer, who is on the work site and supervises the jobs?

Always: ☐ Sometimes: ☐ Never: ☐ Do not know: ☐

5b. When on-site radiography is being performed, is there a qualified radiation safety expert, e.g. a Radiation Protection Officer, who monitors or audits the safe operation of the jobs on a regular basis?

Always: ☐ Sometimes: ☐ Never: ☐ Do not know: ☐

6. Do you check for the presence of the source in the exposure device before taking the device from the store?

Always: ☐ Sometimes: ☐ Never: ☐

7. Do you check for the presence of the source in the exposure device after the NDT test?

Always: ☐ Sometimes: ☐ Never: ☐

8. Have you had any incidents (i.e. deviations from normal, near misses or accidents) (with respect to radiation and hence occupational exposure) during the last 5 years?

Yes: ☐ No: ☐ Do not know: ☐

8a. If yes, how many were there: Deviations from normal? Number =

Near misses? Number =

Accidents? Number =

9. If you had deviations, near misses, or accidents in the last 5 years, did you report these to your company?

Always: ☐ Sometimes: ☐ Never: ☐

9a. If yes to question 9, did your NDT company report any of these to the (radiation protection) regulatory body?

Yes: ☐ No: ☐ Do not know: ☐

9b. If yes to question 9a, which type were reported?

i. All cases: Yes: ☐ No: ☐ Do not know: ☐

ii. Near misses & accidents: Yes: ☐ No: ☐ Do not know: ☐

iii. Accidents only: Yes: ☐ No: ☐ Do not know: ☐

10. Does the NDT company you work for have an emergency plan for site radiography?

Yes: ☐ No: ☐ Do not know: ☐

10a. If yes to question 10, have you received training for the roles and responsibilities of radiographers in that emergency plan?

Yes: ☐ No: ☐ Do not know: ☐

11. Do you use collimators when you perform gamma radiography?

Always: ☐ Sometimes: ☐ Never: ☐

12. Do you use diaphragms/collimators when you perform X ray radiography?

Always: ☐ Sometimes: ☐ Never: ☐

13. Do you know what occupational radiation doses you receive?

Yes: ☐ No: ☐ Do not know: ☐

13a. If yes, how many times per year are you informed about your occupational radiation dose?

Number of times per year =

13b. If yes to Question 13:

i. What was your total occupational dose in 2009:

My dose in 2009 = *(Please specify the units used)*

ii. What was the highest dose you received in a given monitoring period in 2009:

Highest dose in a period = *(Please specify the units used)*

Duration of each monitoring period =

(Please specify whether weeks or months)

iii. What was your radiographic workload in 2009:

Number of films exposed in 2009 =

iv. What type and strength of sources did you use in 2009:

(Please tick all source types that you used in 2009, and fill in the required data per source type used)

Ir-192: ☐	Typical strength =	Ci
	Typical exposure time =	seconds
Se-75: ☐	Typical strength =	Ci
	Typical exposure time =	seconds
Co-60: ☐	Typical strength =	Ci
	Typical exposure time =	seconds
X ray: ☐	Typical voltage =	kV
	Typical current =	mA
	Typical exposure time =	seconds

14. Do you ever discuss your radiation protection issues and/or your occupational doses with your Radiation Protection Officer?

Yes: ☐ No: ☐ Do not know: ☐

14a. If yes, approximately how many times per year would this happen?

Number of times per year =

Requested optional information: *(Note: All information will be treated as strictly confidential by the IAEA. Only anonymised and aggregated data will be made available.)*

Name:

Institution:

Town or city:

Country:

Email:

Date:

I would like to receive the report with the results of this survey: Yes / No

International Atomic Energy Agency

Information System on Occupational Exposure in Medicine, Industry and Research (ISEMIR)

Questionnaire on Occupational Exposure in Industrial Radiography addressed to Operating Companies

The questionnaire should be able to be completed in approximately 20 minutes. It has been developed by the Working Group on Industrial Radiography (WGIR) of ISEMIR. The purpose of this survey is to provide an overview of occupational radiation protection in this area of industry where there still is a potential for workers to be exposed to high levels of radiation as well as the risk of accidents.

The results of the survey will be sent to all participants and made available anonymously on the Networks of Occupational Radiation Protection website at IAEA. The results of the survey will allow IAEA to address recommendations to harmonise and improve radiation protection of workers in industrial radiography.

The completed questionnaire needs to be sent to the IAEA, by email to John.Le.heron@iaea.org or by mail to John Le Heron, Radiation Safety and Monitoring Section (RSM), Division of Radiation, Transport and Waste Safety (NSRW), INTERNATIONAL ATOMIC ENERGY AGENCY, Wagramer Strasse 5, P.O.Box 100, A-1400 Vienna, Austria.

I. Qualifications & training of industrial radiographers in radiation protection

1. Does your Company provide or facilitate radiation protection training for its radiographers?

Yes: ☐ No: ☐ Do not know: ☐

1a. If yes, what kind of radiation protection training do you provide to your operators?

(Please mark all appropriate options — more than one selection is likely. An unmarked option means it is not applicable to your Company.)

☐: Within the Company[7], initial training, theory:	Duration[8]:	hours	
☐: Within the Company, initial training, practical:	Duration:	hours	
☐: Within the Company, refresher training, theory:	Duration:	hours	
	Interval[9]:	months	
☐: Within the Company, refresher training, practical:	Duration:	hours	
	Interval:	months	
☐: Outside the Company[10], initial training, theory:		Duration:	hours
☐: Outside the Company, initial training, practical:	Duration:	hours	
☐: Outside the Company, refresher training, theory:	Duration:	hours	
	Interval:	months	
☐: Outside the Company, refresher training, practical:	Duration:	hours	
	Interval:	months	

[7] Training is provided by the Company itself, using its own resources.

[8] Duration of the radiation protection training in hours.

[9] Interval between one training course and the next, for a given radiographer.

[10] Training is provided by a 3rd party, but the Company requires the radiographer to attend.

1b. If yes to Question 1, do you provide different radiation protection training for gamma sources and for X ray sources?

Yes: ☐ No: ☐

1c. If yes to Question 1, does your training include the following subjects on emergency preparedness and response?

i. Emergency procedures Yes: ☐ No: ☐

ii. Practical exercises for creating a safe situation[11] Yes: ☐ No: ☐

iii. Practical exercises for source recovery Yes: ☐ No: ☐

1d. If your Company does not provide or facilitate radiation protection training, please state the reason:

Reason:

2. Is radiation protection training included as part of NDT–training in Radiographic Testing in your country?

Level 1: Yes: ☐ No: ☐ Do not know: ☐

Level 2: Yes: ☐ No: ☐ Do not know: ☐

Level 3: Yes: ☐ No: ☐ Do not know: ☐

2a. If yes to any of Question 2, does your Company provide or facilitate the radiation protection training that you detailed in Questions 1a,b,c, in addition to this NDT radiation protection training?

Yes: ☐ No: ☐ Do not know: ☐

II. Learning from incidents (deviations from normal, near misses and accidents).

3. How many radiation incidents occurred in your Company during the last five years?

(Please specify or estimate the number for each of the following severity classes. If none occurred in a given category, enter '0' or nil.)

a. Accidents with elevated individual exposures higher than the annual limit:

b. Accidents with elevated individual exposures lower than the annual limit:

c. Near misses that had the potential for elevated individual exposures higher than the annual limit:

d. Near misses that had the potential for elevated individual exposure lower than the annual limit:

e. Other deviations from normal operations:

[11] i.e. after the emergency situation occurs until the source can be recovered.

4. How many radiation incidents did your Company report to the (radiation protection) Regulatory Body during the last five years?

(Please specify or estimate the number for each of the following severity classes. If none occurred in a given category, enter '0' or nil.)

a. Accidents with elevated individual exposures higher than the annual limit:

b. Accidents with elevated individual exposures lower than the annual limit:

c. Near misses that had the potential for elevated individual exposures higher than the annual limit:

d. Near misses that had the potential for elevated individual exposure lower than the annual limit:

e. Other deviations from normal operations:

5. Did your (radiation protection) Regulatory Body report the radiation incidents to the IAEA?

Yes: ☐ No: ☐ Do not know: ☐

6. How does your Company receive information about abnormal individual exposures of its radiographers?

(Please mark all appropriate options — more than one selection is likely. An unmarked option means it is not applicable to your Company.)

☐: From the radiographers (e.g. based on the readout of their active dosimeters);

☐: From your Company's own personal dosimetry service (e.g. based on the collection and readout of active dosimeters);

☐: From your third-party dosimetry service (based on readout of passive dosimeters);

☐: From the regulatory body (based on readout of passive dosimeters);

☐: Other, please specify:

7. How does your Company share information about radiation incidents within your organization?

(Please mark all appropriate options — more than one selection is likely. An unmarked option means it is not applicable to your Company.)

☐: Safety meetings;

☐: Notice boards;

☐: Company Magazine;

☐: Company Intranet;

☐: E-mail notification;

☐: Other, please specify:

8. How does your Company share information about your radiation incidents with other organizations?

(Please mark all appropriate options — more than one selection is likely. An unmarked option means it is not applicable to your Company.)

☐: International or National Incident Database, please specify:

☐: Industry meetings;

☐: E-mail;

☐: Other, please specify:

☐: Company does NOT share incident information with other organizations.

III. Systems and procedures in place for safe operation

9. With regard to individual monitoring, does your Company provide its radiographers with:

a. Passive individual dosimeters: Yes: ☐ No: ☐

b. Active individual dosimeters: Yes: ☐ No: ☐

c. If yes to Question 9b, are the active individual dosimeters equipped with:

i. Visual alarms Yes, all: ☐ Yes, some: ☐ No: ☐

ii. Audible alarms Yes, all: ☐ Yes, some: ☐ No: ☐

iii. Vibrating alarms Yes, all: ☐ Yes, some: ☐ No: ☐

10. Does your Company keep records of the occupational doses received by its radiographers?

Yes: ☐ No: ☐ Do not know: ☐

10a. If yes to Question 10, does your Company inform its radiographers of their personal doses?

Yes: ☐ No: ☐ Do not know: ☐

10b. Are there investigation levels for personal doses established by:

i. Your Company: Yes: ☐ No: ☐ Do not know: ☐

ii. The (radiation protection) Regulatory Body:

Yes: ☐ No: ☐ Do not know: ☐

10c. If yes to either part of Question 10b, how many investigations have been performed by the Company in the last 5 years as a result of the investigation level being exceeded?

Number =

10d. If yes to Question 10, can you please complete the following table:

Number of workers that were in the following ranges of annual individual effective doses in 2009	
Range of annual effective dose, D (mSv)	**Number of Industrial Radiographers**
D < MDL*	
MDL ≤D < 1	
1 ≤ D < 5	
5 ≤ D < 10	
10 ≤ D < 15	
15 ≤ D < 20	
20 ≤ D < 30	
30 ≤ D < 50	
D ≥ 50	

* MDL = Minimum Detection Limit of the personal dosimetry system

11. Does your Company provide any other monitoring or alarm devices?

a. Survey meter Yes: ☐ No: ☐

b. Area monitors: Yes: ☐ No: ☐

c. If yes to Question 11b, are the area monitors equipped with:

i. Visual alarms Yes, all: ☐ Yes, some: ☐ No: ☐

ii. Audible alarms Yes, all: ☐ Yes, some: ☐ No: ☐

d. Other, please specify:

12. With regard to a warning system to prevent entry to the radiography site:

a. At what dose rate does your Company require a warning system to be installed?

Dose rate = microSv/hour

(Please ensure your number is in terms of microSv/hour, otherwise state your units.)

b. What is used as a warning system for the work site:

i. Ribbon or rope Yes: ☐ No: ☐
ii. Passive warning signs Yes: ☐ No: ☐
iii. Active warning signals Yes: ☐ No: ☐
iv. Other, please specify:

13. Has your Company determined the more common causes for unauthorized persons to trespass past the warning system?

Yes: ☐ No: ☐ Do not know: ☐

13a. If yes to Question 13, what are the more common causes?

i. The warning system is not understood: Yes: ☐ No: ☐

ii. Willful violation: Yes: ☐ No: ☐

iii. The warning system was not set up properly to control the area:

Yes: ☐ No: ☐

iv. Other, please specify:

14. Does your Company require its radiographers to announce or warn whenever a radiographic exposure is made?

Yes, every time: ☐ Sometimes: ☐ No: ☐ Do not know: ☐

14a. If yes (every time or sometimes) to Question 14, is this with:

i. An audible alarm (e.g. a siren): Yes: ☐ No: ☐

ii. A visible alarm (e.g. flashing lights): Yes: ☐ No: ☐

iii. An announcement via a public address system: Yes: ☐ No: ☐

iv. Other, please specify:

15. When your Company is providing radiography services in an industrial plant, does the client:

a. Provide your Company with a plan of the installation:

Always: ☐ Sometimes: ☐ Never: ☐

b. Inform your Company about other interfering activities on site:

Always: ☐ Sometimes: ☐ Never: ☐

c. Have a 'permit to work' system:

Always: ☐ Sometimes: ☐ Never: ☐

d. Inform other workers:

i. About the radiography to be performed:

Always: ☐ Sometimes: ☐ Never: ☐

ii. The purpose and method of the warning system (beaconing):

Always: ☐ Sometimes: ☐ Never: ☐

iii. The meaning of alarm signals:

Always: ☐ Sometimes: ☐ Never: ☐

iv. The risks of ionizing radiation / sources:

Always: ☐ Sometimes: ☐ Never: ☐

16. Does your Company require its radiographers to use:

a. Collimators with Gamma radiography: Yes: ☐ No: ☐

b. Diaphragms or collimators with X ray radiography:

Yes: ☐ No: ☐

17. With regard to exposure devices for gamma radiography:

a. What interval does your Company have between preventive maintenance[12]?

Interval = Months

b. What auxiliary equipment is included in the preventive maintenance:

i. Crank	Yes: ☐	No: ☐
ii. Control cable	Yes: ☐	No: ☐
iii. Guide tube	Yes: ☐	No: ☐
iv. Collimator	Yes: ☐	No: ☐
v. Other, please specify:		

c. Who performs the preventive maintenance:

i. Your Company	Yes: ☐	No: ☐
ii. The device manufacturer	Yes: ☐	No: ☐
iii. Other service company	Yes: ☐	No: ☐

18. With regard to X ray equipment:

a. What interval does your Company have between preventive maintenance?

Interval = Months

b. What items / auxiliary equipment are included in the preventive maintenance:

i. Cables	Yes: ☐	No: ☐
ii. Control panel	Yes: ☐	No: ☐
iii. Diaphragm or collimator	Yes: ☐	No: ☐
iv. Output of tube (dose rate)	Yes: ☐	No: ☐
v. Leakage radiation	Yes: ☐	No: ☐
vi. Other, please specify:		

c. Who performs the preventive maintenance:

i. Your Company	Yes: ☐	No: ☐
ii. The device manufacturer	Yes: ☐	No: ☐
iii. Other service company	Yes: ☐	No: ☐

19. Who approved your Company's radiation protection programme?

a. The Managing Director or Chief Executive Officer:	Yes: ☐	No: ☐
b. The Radiation Protection Officer	Yes: ☐	No: ☐
c. The (radiation protection) Regulatory Body	Yes: ☐	No: ☐
d. Other, please specify:		

[12] Preventive maintenance is not the routine checks performed by the radiographer before commencing any radiography work, but rather are the more invasive checks and repair that occur at appropriate intervals.

20. Does your Company perform its own compliance inspections of its radiographers?

Yes: ☐ No: ☐ Do not know: ☐

20a. If yes to Question 20, are there planned compliance inspections?

Yes: ☐ No: ☐ Do not know: ☐

20b. If yes to Question 20, are there unplanned compliance inspections?

Yes: ☐ No: ☐ Do not know: ☐

20c. If yes to Question 20, are these compliance inspections performed by:

i. The Managing Director of your Company Yes: ☐ No: ☐

ii. Other member of the Management Team Yes: ☐ No: ☐

iii. The Radiation Protection Officer Yes: ☐ No: ☐

iv. Other radiation protection expert Yes: ☐ No: ☐

20d. If yes to Question 20, approximately how many times per year[13] would a radiographer be inspected by your Company?

Number of times a radiographer is inspected per year by the Company =

20e. What subjects are addressed during such Company inspections?

i. Proper wearing of passive individual dosimeters: Yes: ☐ No: ☐

ii. Proper wearing and use of active individual dosimeters: Yes: ☐ No: ☐

iii. Proper use of survey meters: Yes: ☐ No: ☐

iv. Proper use of collimators: Yes: ☐ No: ☐

v. Proper warning system at the work site: Yes: ☐ No: ☐

vi. Dose rate at the boundary of the work site within the limits set: Yes: ☐ No: ☐

vii. Proper use of alarm systems (flashing lights, audible alarm, use of PA system): Yes: ☐ No: ☐

viii. Proper training and qualifications of Radiographers: Yes: ☐ No: ☐

ix. Operator knowledge of procedures: Yes: ☐ No: ☐

x. Pre-operation specific equipment checks: Yes: ☐ No: ☐

xi. Equipment condition: Yes: ☐ No: ☐

xii. Emergency preparedness: Yes: ☐ No: ☐

xiii. Other, please specify:

[13] In cases where inspections are 'random', base your estimate on the expected number of inspections in a five year period divided by 5.

20f. Please rank the common shortcomings, in order of the frequency, in which they are observed in these Company inspections?

(Starting with 1 for the most frequent shortcoming, and 2 for the next most frequent, and so on, assign a number (from 1 to 5) to the five most common shortcomings from those listed below, based on your Company's experiences.)

Ranking of your five most common shortcomings:

☐: No proper wearing of passive individual dosimeters;

☐: No proper wear and use of active individual dosimeters;

☐: No proper use of survey meters;

☐: No proper use of collimators;

☐: No proper warning system at the work site;

☐: Dose rate at the boundary of the work site not within limits set;

☐: No proper use of alarm systems (flash lights, audible alarm, use of PA system;

☐: No proper training and qualifications of radiographers;

☐: Poor operator knowledge of procedures;

☐: No pre-operation specific equipment checks being performed;

☐: Poor equipment condition;

☐: Poor emergency preparedness;

☐: Other (see previous question).

21. Does the (radiation protection) Regulatory Body perform planned inspections of your Company's radiographers on the work site?

Yes: ☐ No: ☐ Do not know: ☐

21a. If yes to Question 21, how many times (on average) would a radiographer undergo a planned inspection by the Regulatory Body?

Approximate number of times =

22. Does the (radiation protection) Regulatory Body perform unplanned inspections on your Company's radiographers on the work site?

Yes: ☐ No: ☐ Do not know: ☐

22a. If yes to Question 22, how many times (on average) would a radiographer undergo an unplanned inspection by the Regulatory Body?

Approximate number of times =

IV. Emergency Preparedness and Response

23. Does your Company have an emergency plan and procedures for responding to incidents during the performance of site radiography?

Yes: ☐ No: ☐ Do not know: ☐

23a. With whom does your Company communicate and discuss the emergency plan?

i. Your Company's Radiographers:
Yes: ☐ No: ☐ Do not know: ☐

ii. Your Company's Clients:
Yes: ☐ No: ☐ Do not know: ☐

iii. The (radiation protection) Regulatory Body:
Yes: ☐ No: ☐ Do not know: ☐

iv. Other emergency response authorities:
Yes: ☐ No: ☐ Do not know: ☐

24. Does your Company provide specific training to its radiographers on emergency preparedness and response?

Yes: ☐ No: ☐ Do not know: ☐

24a. If yes to Question 24, does the training include:

i. Explanation of emergency procedures:
Yes: ☐ No: ☐ Do not know: ☐

ii. Practical exercises on containment of the situation, i.e. keeping it safe and under control:
Yes: ☐ No: ☐ Do not know: ☐

iii. Practical exercises on recovery of sources:
Yes: ☐ No: ☐ Do not know: ☐

25. Does your company have emergency equipment for site radiography?

Yes: ☐ No: ☐ Do not know: ☐

25a. If yes to Question 25, what equipment does your Company have: *(more than one answer is likely)*

i. Long tongs: Yes: ☐ No: ☐ Do not know: ☐

ii. Shielding material: Yes: ☐ No: ☐ Do not know: ☐

iii. Emergency/Rescue container: Yes: ☐ No: ☐ Do not know: ☐

iv. Other, please specify:

25b. If yes to Question 25, do your radiographers have access to the emergency equipment? Yes: ☐ No: ☐ Do not know: ☐

26. In your Company's Emergency Plan, who is responsible for the following stages of an emergency?

a. Containment of the situation, i.e. keeping it safe and under control:

(Mark only those appropriate to your Emergency Plan)

☐: Radiographer

☐: Radiation Protection Officer/Radiation Protection Expert

☐: Other Qualified Expert: specify:

☐: Authorities: specify which authority:

☐: Appointed institute: specify type of institute:

b. Planning and rehearsing the Recovery *(see also following stage)*

(Mark only those appropriate to your Emergency Plan)

☐: Radiographer

☐: Radiation Protection Officer/Radiation Protection Expert

☐: Other Qualified Expert: specify:

☐: Authorities: specify which authority:

☐: Appointed institute: specify type of institute:

c. Recovery of the situation:

(Mark only those appropriate to your Emergency Plan)

☐: Radiographer

☐: Radiation Protection Officer/Radiation Protection Expert

☐: Other Qualified Expert: specify:

☐: Authorities: specify which authority:

☐: Appointed institute: specify type of institute:

d. Investigation and reporting:

(Mark only those appropriate to your Emergency Plan)

☐: Radiographer

☐: Radiation Protection Officer/Radiation Protection Expert

☐: Other Qualified Expert: specify:

☐: Authorities: specify which authority:

☐: Appointed institute: specify type of institute:

27. Does your Company hold emergency exercises to test the critical components of the Company's Emergency Plan?

Yes: ☐ No: ☐ Do not know: ☐

27a. If yes to Question 27, how often does your Company hold these exercises?

Number = per year

28. Does your Company undertake a periodic formal review of its Emergency Plan?

Yes: ☐ No: ☐ Do not know: ☐

28a. If yes to Question 28, how often does your Company undertake a review?

Number = per year

V. Company 'profile'

29. What radiographic techniques does your Company utilize? *(Tick only one box)*

a. Gamma radiography only? ☐

b. X ray radiography only? ☐

c. Both Gamma and X ray radiography? ☐

30. How many radiographers does your Company employ (approximately)?

a. By type of contract:

i. Number of full-time contract radiographers =

ii. Number of part-time contract radiographers =

iii. Number of itinerant radiographers =

b. By work location:

i. Number of radiographers working at base =

ii. Number of radiographers working at client sites =

iii. Number of radiographers working both at base and at client-sites =

c. By type of NDT radiography:

i. Number of radiographers that only perform Gamma radiography =

ii. Number of radiographers that only perform X ray radiography =

iii. Number of radiographers that perform both Gamma and X ray radiography =

iv. Number of radiographers that also perform other non RT NDT methods=

31. Does your Company have a Radiation Protection Officer or Radiation Protection Expert included in its organization?

Yes: ☐ No: ☐ Do not know: ☐

31a. If yes to Question 31, does he/she report directly to the Managing Director?

Yes: ☐ No: ☐ Do not know: ☐

Requested optional information: *(Note: All information will be treated as strictly confidential by the IAEA. Only anonymised and aggregated data will be made available.)*

Name:

Job title or position:

Institution:

Town or city:

Country:

Email:

Date

I would like to receive the report with the results of this survey: Yes / No

IV.3. QUESTIONNAIRE DISTRIBUTED TO THE REGULATORY BODIES

International Atomic Energy Agency

Information System on Occupational Exposure in Medicine, Industry and Research (ISEMIR)

Questionnaire on Occupational Exposure in Industrial Radiography addressed to the National or State (Radiation Protection) Regulatory Body

This questionnaire has been developed by the Working Group on Industrial Radiography (WGIR) of ISEMIR. The purpose of this survey is to provide an overview of occupational radiation protection in this area of industry where there still is a potential for workers to be exposed to high levels of radiation as well as the risk of accidents.

The results of the survey will be sent to all participants and made available anonymously on the Occupational Radiation Protection Networks (ORPNET) website at IAEA. The results of the survey will allow IAEA to address recommendations to harmonize and improve radiation protection of workers in industrial radiography.

I. Training and Qualifications of Industrial Radiographers

1. Does the (radiation protection) Regulatory Body require that persons wishing to perform on-site[14] radiography must have had radiation protection training to an acceptable level?

Yes: ☐ No: ☐ Do not know: ☐

1a. If yes to Question 1, what radiation protection training does the Regulatory Body consider as acceptable?

i. Radiation protection training that is part of the NDT-training on Radiographic Testing?

Yes: ☐ No: ☐ Do not know: ☐

ii. Radiation protection training that is a separate training course?

Yes: ☐ No: ☐ Do not know: ☐

1b. If yes to Question 1, does the Regulatory Body have the same radiation protection training requirements for using gamma sources as for using X ray machines?

Yes: ☐ No: ☐ Do not know: ☐

1c. If yes to Question 1, does the Regulatory Body require that the radiation protection training includes both theoretical and practical training?

Yes: ☐ No: ☐ Do not know: ☐

[14] On-site means on the site of the client and not in a fixed facility designed for radiography.

1d. If yes to Question 1, does the Regulatory Body require that the radiation protection training includes practical exercises for emergencies, namely for:

i. Creating a safe situation until the source is able to be recovered?

Yes: ☐ No: ☐ Do not know: ☐

ii. Source recovery?

Yes: ☐ No: ☐ Do not know: ☐

1e. If yes to Question 1, does having the acceptable level of radiation protection training (either as part of the NDT programme or as separate training) include having passed an examination at the end of the radiation protection training?

Yes: ☐ No: ☐ Do not know: ☐

1f. If yes to Question 1e, is the examination on radiation protection:

(Please mark only one option)

☐ Theoretical only;

☐ Practical only;

☐ Both theoretical and practical.

1g. If yes to Question 1a(ii), are the separate training courses conducted by:

i. The (radiation protection) Regulatory Body:

Yes: ☐ No: ☐ Do not know: ☐

ii. Educational institutes (such as Universities, Polytechnics, Trades training Schools):

Yes: ☐ No: ☐ Do not know: ☐

iii. Private NDT companies:

Yes: ☐ No: ☐ Do not know: ☐

iv. Private Radiation Protection consultants:

Yes: ☐ No: ☐ Do not know: ☐

v. Other, please specify:

2. Does the (radiation protection) Regulatory Body require refresher training in radiation protection for persons performing on-site radiography?

Yes: ☐ No: ☐ Do not know: ☐

2a. If yes to Question 2, what is the time interval between refresher courses?

A refresher course every: years

2b. If yes to Question 2, is there an examination as part of the refresher training?

Yes: ☐ No: ☐ Do not know: ☐

3. Does the (radiation protection) Regulatory Body require that a person wishing to act as a Radiation Protection Officer[15] (RPO) for a Company that performs on-site radiography must have had radiation protection training to an acceptable level?

Yes: ☐ No: ☐ Do not know: ☐

3a. If yes to Question 3, is the acceptable level higher than that for an operator (as in Question 1)?

Yes: ☐ No: ☐ Do not know: ☐

3b. If yes to Question 3, is there an examination as part of the training to be an RPO?

Yes: ☐ No: ☐ Do not know: ☐

II. Incidents (deviations, near misses and accidents).

4. Does the (radiation protection) Regulatory Body require the authorized party (licensee) to report radiation incidents in Industrial Radiography to the Regulatory Body?

Yes: ☐ No: ☐ Do not know: ☐

4a. If yes to Question 4, what are the criteria for requiring a licensee to notify the Regulatory Body?

Please specify:

5. How many radiation incidents in Industrial Radiography were notified to the (radiation protection) Regulatory Body in the last five years?

(Please specify or estimate the number for each of the following severity classes. If none occurred in a given category, enter '0' or nil.)

a. Accidents with elevated individual exposures higher than the annual limit:
b. Accidents with elevated individual exposures lower than the annual limit:
c. Near misses that had the potential for elevated individual exposures higher than the annual limit:
d. Near misses that had the potential for elevated individual exposure lower than the annual limit:
e. Other deviations from normal operations:

6. Does the (radiation protection) Regulatory Body maintain a radiation incident database for your jurisdiction (country or state)?

Yes: ☐ No: ☐ Do not know: ☐

[15] RPO means a person technically competent in radiation protection matters relevant, in this case, to industrial radiography who is designated by the licensee to oversee the application of relevant radiation protection requirements established in national regulations.

6a. If yes to Question 6, does the Regulatory Body analyse the database regularly, using established criteria, to determine if there are common factors in the incidents?

Yes: ☐ No: ☐ Do not know: ☐

6b. If yes to Question 6, does the Regulatory Body use the International Nuclear and Radiological Event Scale (INES) to classify the severity of the incidents?

Yes: ☐ No: ☐ Do not know: ☐

6c. If no to Question 6b, does the Regulatory Body use another scale to classify the severity of the incidents

Yes: ☐ No: ☐ Do not know: ☐

6d. If yes to Question 6c, please specify:

7. Does the (radiation protection) Regulatory Body have an established system for sharing lessons learned from reported incidents, including an analysis of the root causes and the corrective actions taken?

Yes: ☐ No: ☐ Do not know: ☐

7a. If yes to Question 7, to whom is the information disseminated?

i. Operating NDT companies in your jurisdiction?

Yes: ☐ No: ☐ Do not know: ☐

ii. Other regulatory bodies in other countries or states?

Yes: ☐ No: ☐ Do not know: ☐

7b. If yes to Question 7, how many times in the last 5 years has information from reported incidents been disseminated to:

(Enter 0, or nil if there has been no disseminations.)

i. Operating NDT companies in your jurisdiction:

ii. Other regulatory bodies in other countries or states:

8. If you are the national (radiation protection) Regulatory Body, did you report the incidents to the International Atomic Energy Agency (IAEA) in the last 5 years?

Yes: ☐ No: ☐ Do not know: ☐

III. Systems and procedures in place to ensure protection and safety in industrial radiography

III.1 Safety of the radiographer

9. What type of individual monitoring does the (radiation protection) Regulatory Body require the radiographer to have?

a. Passive dosimeter[16]:

Yes: ☐ No: ☐ Do not know: ☐

[16] Such as thermoluminescence (TLD), optically stimulated luminescence (OSL), film or radiophotoluminescence (RPL) dosimeter.

b. Active dosimeter (Electronic Personal Dosimeter):

Yes: ☐ No: ☐ Do not know: ☐

9c. If yes to part b, is the active dosimeter required to measure integrated dose:

Yes: ☐ No: ☐ Do not know: ☐

9d. If yes to part b, is the active dosimeter required to have:

i. A visual alarm:

Yes: ☐ No: ☐ Do not know: ☐

ii. An audible alarm:

Yes: ☐ No: ☐ Do not know: ☐

iii. A vibrating alarm:

Yes: ☐ No: ☐ Do not know: ☐

10. Whom does the (radiation protection) Regulatory Body require to be informed about the personal doses of the monitored radiographers?

a. The radiographer?

Yes: ☐ No: ☐ Do not know: ☐

If yes, frequency per year =

b. The NDT Company or employer of the radiographer?

Yes: ☐ No: ☐ Do not know: ☐

If yes, frequency per year =

c. The (radiation protection) Regulatory Body?

Yes: ☐ No: ☐ Do not know: ☐

If yes, frequency per year =

d. The National Personal Dose Database?

Yes: ☐ No: ☐ Do not know: ☐

If yes, frequency per year =

11. Does the (radiation protection) Regulatory Body require that the radiographer always has a functioning and calibrated survey meter with them?

Yes: ☐ No: ☐ Do not know: ☐

III.2 Safety of the public

12. Does the (radiation protection) Regulatory Body require that it is informed in advance about individual on-site Industrial Radiography jobs?

Yes: ☐ No: ☐ Do not know: ☐

12a. If yes to Question 12, how long in advance must the notification be?

Please specify: hours

13. Does the (radiation protection) Regulatory Body require there to be a warning system to prevent entry to the radiography site?

Yes: ☐ No: ☐ Do not know: ☐

13a. If yes to Question 13, does the Regulatory Body have an official standard procedure for warning systems that must be followed?

Yes: ☐ No: ☐ Do not know: ☐

13b. If yes to Question 13a, does the official standard procedure for a warning system require:

i. Barriers:

Yes: ☐ No: ☐ Do not know: ☐

ii. Warning signs:

Yes: ☐ No: ☐ Do not know: ☐

iii. Flashing lights:

Yes: ☐ No: ☐ Do not know: ☐

iv. Other features:

Yes: ☐ No: ☐ Do not know: ☐

If yes, please specify:

13c. If yes to Question 13a, what maximum dose rate does the official standard procedure specify at the barrier:

Please specify: microSv/hour

(Please ensure your number is in terms of microSv/hour, otherwise state your units.)

14. Does the (radiation protection) Regulatory Body require the client (who is receiving the on-site radiography services) to inform the licensee (of the Operating NDT Company) about conditions at the site that might affect the safety of other workers on site?

Yes: ☐ No: ☐ Do not know: ☐

14a. If yes to Question 14, does this include:

i. The provision of site plans?

Yes: ☐ No: ☐ Do not know: ☐

ii. Information about other worker activities, occurring at the same time and in the vicinity of where the radiography will occur?

Yes: ☐ No: ☐ Do not know: ☐

15. Does the (radiation protection) Regulatory Body require that there is a qualified Radiation Protection Officer (RPO) or Radiation Protection Expert[17] (RPE) on the work site during on-site radiography?

Yes: ☐ No: ☐ Do not know: ☐

[17] A Radiation Protection Expert is a person having the knowledge, training and experience needed to give radiation protection advice in order to ensure effective protection of individuals, whose capacity to act is recognized by the competent authorities.

III.3 Safety of sources and exposure devices

16. Does the (radiation protection) Regulatory Body require that any sealed source used for industrial radiography purposes must meet specified standards:

Yes: ☐ No: ☐ Do not know: ☐

16a. If yes to Question 16, please specify the standards:

17. Does the (radiation protection) Regulatory Body require that any exposure device used for industrial radiography purposes must meet specified standards:

Yes: ☐ No: ☐ Do not know: ☐

17a. If yes to Question 17, please specify the standards:

18. Does the (radiation protection) Regulatory Body require that the source and the exposure device are subject to rigorous periodic inspections/tests and maintenance to verify compliance with required standards?

Yes: ☐ No: ☐ Do not know: ☐

18a. If yes to Question 18, what is the required frequency:

Please specify:

18b. If yes to Question 18, are accessories included?

Yes: ☐ No: ☐ Do not know: ☐

18c. If yes to Question 18, who is permitted by the Regulatory Body to perform such services?

i. The manufacturer or manufacturer's agent:

Yes: ☐ No: ☐ Do not know: ☐

ii. The NDT Operating Company:

Yes: ☐ No: ☐ Do not know: ☐

iii. Other third party:

Yes: ☐ No: ☐ Do not know: ☐

If yes, please specify:

19. Does the (radiation protection) Regulatory Body require that any X ray generator used for industrial radiography purposes must meet specified standards:

Yes: ☐ No: ☐ Do not know: ☐

19a. If yes to Question 19, please specify the standards:

20. Does the (radiation protection) Regulatory Body require that the X ray equipment are subject to rigorous periodic inspections/tests and maintenance to verify compliance with required standards?

Yes: ☐ No: ☐ Do not know: ☐

20a. If yes to Question 20, what is the required frequency:

Please specify:

20b. If yes to Question 20, are accessories included?

Yes: ☐ No: ☐ Do not know: ☐

20c. If yes to Question 20, who is permitted by the Regulatory Body to perform such services?

i. The manufacturer or manufacturer's agent:

Yes: ☐ No: ☐ Do not know: ☐

ii. The NDT Operating Company:

Yes: ☐ No: ☐ Do not know: ☐

iii. Other third party:

Yes: ☐ No: ☐ Do not know: ☐

If yes, please specify:

21. Does the (radiation protection) Regulatory Body specify requirements for on-site storage of sources?

Yes: ☐ No: ☐ Do not know: ☐

22. Does the (radiation protection) Regulatory Body require the licensee to conduct periodic documented checks of sources to confirm that they are in their assigned locations and are secure?

Yes: ☐ No: ☐ Do not know: ☐

III.4 Regulatory inspections and radiation protection officers

23. Does the (radiation protection) Regulatory Body perform inspections of NDT Operating Companies that provide on-site radiography services?

Yes: ☐ No: ☐ Do not know: ☐

23a. If yes to Question 23, are these inspections to where on-site radiography is actually taking place?

Yes: ☐ No: ☐ Do not know: ☐

23b. If yes to Question 23, are these inspections:

(Please mark only one option)

☐ Announced only;

☐ Unannounced only;

☐ Either announced or unannounced;

☐ Do not know.

23c. If yes to Question 23, how often is a given licensee inspected?

Please specify the frequency:

23d. If yes to Question 23, are the following addressed during the inspections?

i. Proper wearing of passive individual dosimeters Yes: ☐ No: ☐

ii. Proper wearing and use of active individual dosimeters Yes: ☐ No: ☐

iii. Proper use of survey meters Yes: ☐ No: ☐

iv. Proper use of collimators Yes: ☐ No: ☐

v. Proper use of warning systems to prevent entry at the work site
Yes: ☐ No: ☐

vi. Dose rate at the boundary of the warning system to prevent entry to the work site within limits set: Yes: ☐ No: ☐

vii. Proper use of alarm systems (flashing lights, audible alarm, use of PA system):
Yes: ☐ No: ☐

viii. Proper training and qualifications of Industrial Radiographers
Yes: ☐ No: ☐

ix. Operator knowledge of procedures: Yes: ☐ No: ☐

x. Pre-operation specific equipment checks: Yes: ☐ No: ☐

xi. Equipment condition: Yes: ☐ No: ☐

xii. Emergency preparedness: Yes: ☐ No: ☐

xiii. Other, please specify:

23e. If yes to Question 23, please rank the common shortcomings, in order of the frequency, in which they are observed in inspections?

(Starting with 1 for the most frequent shortcoming, and 2 for the next most frequent, and so on, assign a number (from 1 to 5) to the five most common shortcomings from those listed below, based on your experiences.)

Ranking of the five most common shortcomings:

- ☐ No proper wearing of passive individual dosimeters;
- ☐ No proper wearing and use of active individual dosimeters;
- ☐ No proper use of survey meters;
- ☐ No proper use of collimators;
- ☐ No proper warning system to prevent entry to the work site;
- ☐ Dose rate at the boundary of the work site not within limits set;
- ☐ No proper use of alarm systems (flash lights, audible alarm, use of PA system;
- ☐ No proper training and qualifications of radiographers;
- ☐ Poor operator knowledge of procedures;
- ☐ No pre-operation specific equipment checks being performed;
- ☐ Poor equipment condition;
- ☐ Poor emergency preparedness;
- ☐ Other (see previous question).

24. Does the (radiation protection) Regulatory Body require that a licensee (NDT Operating Company) employs a Radiation Protection Officer (RPO) or Radiation Protection Expert (RPE)?

Yes: ☐ No: ☐ Do not know: ☐

24a. If yes to Question 24, does the regulatory body require that the RPO or RPE reports directly to the Managing Director[18] of the Company?

Yes: ☐ No: ☐ Do not know: ☐

III.5 Emergency plan

25. Does the (radiation protection) Regulatory Body require that a licensee (NDT Operating Company) has an Emergency Plan?

Yes: ☐ No: ☐ Do not know: ☐

25a. If yes to Question 25, does the Regulatory Body require that the Emergency Plan specifies requirements for training and exercises?

Yes: ☐ No: ☐ Do not know: ☐

25b. If yes to Question 25, does the Regulatory Body approve the licensee's Emergency Plan?

Yes: ☐ No: ☐ Do not know: ☐

26. Does the (radiation protection) Regulatory Body require that licensees must have emergency equipment?

Yes: ☐ No: ☐ Do not know: ☐

27. Does the (radiation protection) Regulatory Body have resources to assist licensees in recovering from emergencies?

Yes: ☐ No: ☐ Do not know: ☐

28. Does the (radiation protection) Regulatory Body check the Emergency Plan and the list of emergency equipment for radiographic work during the periodic inspection or at licence renewal for the NDT Operating Company?

Yes: ☐ No: ☐ Do not know: ☐

[18] Or other equivalent person, such as Chief Executive Officer

IV. Individual monitoring.

29. Does the (radiation protection) Regulatory Body have direct access to a national or state database of individual doses for Industrial Radiographers and other involved in NDT?

Yes: ☐ No: ☐ Do not know: ☐

29a. If yes to Question 29, please complete the following table:

Table 1: Number of NDT workers with individual dosimetry in 2009	
Category of person	*Number monitored in 2009*
Industrial radiographers	
Other exposed NDT workers	
All exposed workers*	

* The sum of industrial radiographers and other exposed NDT workers

29b. If yes to Question 29, please complete the following table:

Table 2: Annual occupational doses for NDT workers in 2009			
Category of person	Average annual individual effective dose (mSv)	Median annual individual effective dose (mSv)	Highest annual individual effective dose (mSv)
Industrial radiographers			
Other exposed NDT workers			
All exposed workers*			

* The sum of industrial radiographers and other exposed NDT workers.

29c. If yes to Question 29, please complete the following table:

Table 3: Number of workers that were in the following ranges of annual individual effective doses in 2009			
Ranges of annual individual effective dose, D, (mSv)	Industrial Radiographers	Other exposed NDT workers	All exposed workers**
D < MDL*			
MDL ≤D < 1			
1 ≤ D < 5			
5 ≤ D < 10			
10 ≤ D < 15			
15 ≤ D < 20			
20 ≤ D < 30			
30 ≤ D < 50			
D ≥ 50			

* MDL= Minimum Detection Limit of the personal dosimetry system.

** The sum of industrial radiographers and other exposed NDT workers.

29d. If yes to Question 29, please complete the following table:

Table 4: Number of workers whose maximum individual effective dose in a month in 2009 was in the following ranges			
Ranges of maximum individual effective dose in a month, D_m,(mSv)	Industrial Radiographers	Other exposed NDT workers	All exposed workers*
$D_m < 1$			
$1 \leq D_m < 2.5$			
$2.5 \leq D_m < 5$			
$5 \leq D_m < 10$			
$10 \leq D_m < 20$			
$20 \leq D_m < 50$			
$D_m \geq 50$			

* The sum of industrial radiographers and other exposed NDT workers.

29e. If yes to Question 29, do the above given dose records include doses received from performing industrial radiography on-site at Nuclear Power Plants?

Yes: ☐ No: ☐ Do not know: ☐

29f. If yes to Question 29, does the Regulatory Body perform trend analyses (over, for example, 5 years or more) of occupational doses in industrial radiography, in particular for the most exposed workers, and correlate these with incidents?

Yes: ☐ No: ☐ Do not know: ☐

29g. If yes to Question 29f, are the results used by the Regulatory Body, in conjunction with the NDT industry, to initiate measures to reduce the likelihood of such incidents recurring?

Yes: ☐ No: ☐ Do not know: ☐

Requested optional information: *(Note: All information will be treated as strictly confidential by the IAEA. Only anonymised and aggregated data will be made available.)*

Name:

Job title or position:

Institution:

Town or city:

Country:

Email:

Date

I would like to receive the report with the results of this survey: Yes: ☐ No: ☐

APPENDIX V. MEMBERS OF THE ISEMIR WORKING GROUP ON INDUSTRIAL RADIOGRAPHY (WGIR)

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