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Committee on Radiation Protection and Public Health

Information and Regulatory Issues for the Management of International Outside Workers and Integration of Risk Management at Nuclear Power Plants

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Radiological Protection

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, the Republic of Korea, the Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

FOREWORD

The NEA has long been interested in issues relating to application of the radiation protection principles and criteria as are stated in relevant ICRP Recommendations. The Committee on Radiation Protection and Public Health (CRPPH), one of the NEA standing technical committees, agreed at its 64th meeting (in 2006) to create the Expert Group on Occupational Exposure (EGOE) to broadly scope out policy and regulatory issues that could be usefully addressed by the CRPPH in occupational radiation protection across many sectors, with a focus on the nuclear power industry. After the investigations, discussions and initial scoping work, the group was tasked with work on three topical subjects in separate case studies:

- *Case Study 1*: Occupational radiation protection principles and criteria for designing new nuclear power plants.
- *Case Study 2*: Dose constraints in occupational radiation protection.
- *Case Study 3*: Information and regulatory issues for the management of international outside workers, and integration of risk management at nuclear power plants.

Case Study 1 was completed and published as an NEA publication in 2010 (OECD/NEA). Following the step-by-step approach advised to the group by the CRPPH, the EGOE continued its work and prepared and finalised the draft of Case Study 2, which was submitted to, and approved by, the CRPPH at its 69th meeting in 2011.

Case Study 2 was completed and published as an NEA publication in 2011 (OECD/NEA). Case Study 2 addresses and elaborates on current understanding and use of the concept of dose constraints and optimisation of protection, as they are already implemented in regulatory practices, and used in radiation protection approaches in utilities. The case study also introduces approaches that are being used or considered for dose constraints as this concept is now proposed by the ICRP.

Case Study 3 focuses on two topics: managing compliance with dose limits applicable to and the dosimetry records of outside workers, and enhancing the integrated management of risks related to a facility's operation. The report was completed through intensive work of all group members nominated by the CRPPH, and was accomplished during EGOE meetings throughout 2011-2012.

The NEA wishes to acknowledge this work and co-operation, which helped to complete the drafting of this publication in a timely fashion.

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LIST OF ACRONYMS

ALARA	As low as reasonable achievable
ALARP	As low as reasonably practicable
ASARA	As safely as reasonably achievable
BSS	IAEA International Basic Safety Standards
CNSC	Canadian Nuclear Safety Commission
CRPPH	Committee on Radiation Protection and Public Health
CY	Calendar year
EGOE	Expert Group on Occupational Exposure
EURATOM	European Atomic Energy Community
EU	European Union
EC	European Commission
HERCA	Heads of the European Radiological Protection Competent Authorities
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ILO	International Labour Organization
INPO	Institute of Nuclear Power Operations
ISOE	Information System on Occupational Exposure
NAEA	National Atomic Energy Agency
NDR	National Dose Registry
NEA	OECD Nuclear Energy Agency
NPP	Nuclear power plant
ORP	Occupational radiation protection
RP	Radiation protection
STUK	Radiation and Nuclear Safety Authority (Finland)
TEDE	Total effective dose equivalent
WANO	World Association of Nuclear Operators
WHO	World Health Organization
USDOE	United States Department of Energy
USNRC	United States Nuclear Regulatory Commission

EXECUTIVE SUMMARY

The NEA Committee on Radiation Protection and Public Health (CRPPH) created the *ad hoc* Expert Group on Occupational Exposure (EGOE), tasking it with investigating policy and regulatory issues that might usefully be addressed to benefit users of radioactive materials and the regulators of those uses. This document is the third case study by EGOE for CRPPH and focuses on two topics:

- managing compliance with dose limits applicable to and the dosimetry records of international outside workers;
- enhancing the integrated management of risks related to a facility's operation.

To make the best use of the human resources available to the nuclear industry, and to use the talents of the highly specialised workers within that group of workers, operators of undertakings (e.g. a nuclear power plant) may arrange for contracted personnel to work on a temporary basis in the controlled area of the facility (often called "outside workers" or "supplemental workers"). These workers may be self-employed or employed by a different organisation in the same country, or by an organisation in a different country. Especially when the personnel work in different countries, obtaining and managing the dosimetry records of the individuals is important, both for ensuring the doses to the individuals remain in compliance with applicable dose limits and constraints and also to facilitate the management of doses via the relevant programmes to maintain doses as low as reasonably achievable (ALARA).

The EGOE reviewed the efforts of the International Atomic Energy Agency (IAEA) and the Heads of European Radiological Protection Competent Authorities (HERCA) in addressing the topic of outside workers. It also conducted a survey on national practices for international outside workers among CRPPH member countries to determine how countries handle the situation of internationally migrating workers.

EGOE found that national regulations about radiation protection serve national needs and end at national borders. Therefore, regulations and monitoring practices often differ between the various countries. Workers traversing national borders to find work (and the employers of those workers) then have to cope with regulatory inconsistencies and conflicts between the different countries involved. Via the European Union Basic Safety Standards and the recommendations of the harmonised European Radiation Passbook, the situation is improving in Europe. The IAEA is also working on a safety report on radiation protection of itinerant workers. It is, however, not expected that international agreements on all outside workers will be formally established in the near future, although EGOE encourages continued efforts toward that objective.

EGOE observes that the contractual agreements between the operating facility and the worker's employer are important instruments in addressing means to cope with the differences in regulations of the various involved governments. Those arrangements can stipulate the responsibilities of the involved contract partners and any administrative dose constraints that may be adopted to ensure compliance with dose limits in countries where the worker is anticipated to be employed, and thereby help to protect the livelihood of the worker. Notably, the outside worker is the primary link in ensuring that dose recording and reporting meets the needs of the worker as he or she moves from country to country for temporary work. The worker should not rely solely on the care of

employer, undertaking, and/or regulator for adequacy of dose recording and reporting. The worker should also be aware of the self-responsibility for maintaining an up-to-date dose history, ensuring availability of relevant certificates of employability, and maintaining dose as low as reasonably achievable.

In addressing the second topic of this case study (integrated risk management), EGOE began by observing that well-run facilities are managed with a strong emphasis on worker safety and that of the public, to guard against all kinds of contributors to risk. A facility's having a robust safety culture is endorsed by organisations such as the IAEA, the World Association of Nuclear Operators, and the Institute for Nuclear Power Operations, as well as the companies operating the facilities, and the regulators providing oversight for those facilities.

Achieving a strong safety culture is hampered in some facilities and some regulatory bodies, where the safety functions are organisationally fragmented, with different contributors to risk being the purview of different departments. Also, the risks from different contributors are often expressed using different and sometimes virtually incompatible measures of risk.

EGOE noted the encouragement to move toward a coherent and integrated concept of all workplace risks via organisations such as the IAEA, the International Labour Organization, the World Health Organization, the European Union, and the nuclear industry. The EGOE describes in this document some commonalities for purposes of risk reduction as evidenced via well-run work management programmes, including the use of multi-disciplinary, structured, self-critical approaches for risk assessment and mitigation. A key objective is the allocation of resources for health and safety which is based on a rational balance between all risks. That balance may be expected to change over time, so that facility operators and regulators need to remain aware of emerging changes as societal perspectives on risk, scientific understandings of risks and their interactions, and work performance techniques evolve.

EGOE provides several attributes it considers important for risk assessment and mitigation. Management attention, for example, is important in demanding the (operating and/or regulatory) staff's consideration of relevant risks, and the bridging of any communications gaps that may arise in describing risks, outlining potential risk mitigation techniques, and making balanced risk decisions. The work management process may be used effectively in integrated risk management, with the assurance of multi-disciplinary involvement in work selection, planning, scheduling, and execution. Facility- and job-specific situations are likely to mandate the use of case-by-case approaches to risk evaluation and mitigation, with human error reduction techniques used to promote the excellence of analyses and the decision making based on those analyses.

EGOE acknowledges that at this time, some decisions on risk mitigation must be made using professional experience and professional judgment, informed by best practices at well-managed facilities and regulators. EGOE encourages efforts toward the development of training courses on the integrated management of risks, using practical examples and addressing management's best judgment on the adequate and desired elements of workplace and facility safety. Contents of such a course may evolve with time, as more data emerges on means to better compare and contrast risks and their potential consequences using more quantifiable factors.

1. INTRODUCTION AND SCOPE

When the NEA Committee on Radiation Protection and Public Health (CRPPH) created the *ad hoc* Expert Group on Occupational Exposure (EGOE), it tasked the group with exploring policy and regulatory issues that might usefully be addressed to benefit users of radioactive materials and the regulators of those uses, in particular the nuclear power industry. As part of the EGOE's discussions, it considered various issues for exploration, previously resulting in two published case studies, the first regarding plant design as an important element in occupational radiation protection (ORP), and the second regarding the use of dose constraints in implementing an ORP programme. Further, EGOE discussed multiple other topics, including contributions that it might make regarding holistic approaches to risk management, the promotion of safety culture, and operational lessons drawn from a review of programmes in use to ensure exposures of workers were maintained at levels which are ALARA. Out of these discussions arose this case study.

The experience of past decades shows that ORP programmes have been very successful in reducing the radiation doses received by workers during the operation, maintenance, and refuelling phases of nuclear power plants. Nonetheless, there remains the need to continue to investigate means of reasonably achieving still lower radiation doses to workers, without those means resulting in unplanned or excessive increases in other contributors to risk to workers or the public, or to unacceptable consequences to safe and reliable facility operation. In thinking through such a concept, the reader may recognise that rarely, if ever, is ORP implemented without its programme elements affecting or being affected by elements of other plant programmes, such as industrial safety, reactor safety, and environmental safety. Additionally, rarely if ever can an ORP programme at a facility be managed solely considering the staff employed permanently by that facility. That is because contracted personnel are called upon to provide services that are very specialised in nature or that require significant numbers of personnel for temporary periods of time, such as for maintenance or refuelling outages.

In developing this case study, several guiding principles were found to apply. The first is that co-operation, communication, and multidisciplinary approaches are needed within the facility staff to ensure that all relevant factors are considered in decision making. The second is that there is a similar need for multidisciplinary communications among organisations, such as the facility staff, contractors, and regulators in developing and assessing effective programmes. A third is the proactive implementation of lessons learned over recent years, especially as they may apply to situations that may be expected to become more prevalent in coming years.

As EGOE discussed the various potential topics for this case study, it decided to focus on an audience of senior managers at nuclear facilities (including the manager of radiation protection), senior managers of organisations providing outside workers for those facilities, and senior managers of regulatory agencies providing oversight of the facilities.

This case study provides input for policy decisions and technical application in two areas:

- Information and regulatory issues for the management of international outside workers specifically related to managing dosimetry records for those workers and ensuring compliance with applicable dose limits and constraints for those workers. International movement of contracted personnel is not only common but is increasing in frequency.
- Integration of risk management at nuclear power plants. The objective is the definition of an approach which results in the optimised allocation of resources to ORP and other programmes and a rational balance between the various risks related to facility operation. The balancing of risks and the optimising of resource allocations should result in a facility's operating with the lowest reasonably achievable risk, which may or may not equate to the lowest achievable risk due to radiation exposure of the workers.

The expertise of the members of the EGOE relates primarily to workplace risks and more specifically to risks related to occupational radiation exposure. In this case study, EGOE intentionally uses broader language than only "risk to workers" to indicate that while workplace risks are themselves complex to balance, an even more complex balancing of risks is needed to fully address all of the relevant risk-related factors for plant operations. This requires co-operation and multidisciplinary decision making by facility operators and regulators.

2. INFORMATION AND REGULATORY ISSUES FOR THE MANAGEMENT OF INTERNATIONAL OUTSIDE WORKERS

International outside workers, surrounding legal issues

Outside workers are defined as workers who are working on a temporary basis in the controlled area of an undertaking (usually a nuclear power plant) and are not directly employed by the operator of the undertaking. These workers may be self-employed or employed by a different organisation in the same country, or by an organisation in a different country, either within or outside the OECD/NEA member countries. It is almost always the case that such workers are subject to national laws and requirements applicable to their place of temporary employment. To ensure compliance, the undertaking that contracts the employer of an outside worker is usually required to obtain all relevant records for the temporary worker at the time of initiation of temporary employment. These records are needed in order to determine if the worker is and will be in compliance with all national/local laws. The required records usually include RP training, respirator training, medical fitness reports, doses received during the current monitoring period and possibly dose history, intakes of radioactive materials, and other relevant data.

One difficulty lies in deciding what form of records would be acceptable to the local undertaking, how to transmit the data between employers, how to allow for the fact that different countries may have different dose limits and constraints, and how to address the situation if the permanent employer wishes to impose constraints on its workers that must be observed in order for them to continue working in radiation areas.

Another issue of concern is to ensure the integrity of the data as it is transmitted between employers. There are at present no universally agreed upon methods to accomplish such record transfers, but many countries have devised national practices for the monitoring of outside workers. One such practice is use of a radiation passbook, which is used to document official and operational doses, RP training, and medical fitness. The passbook is carried physically by the worker as he or she moves from site to site, and is officially updated and stamped by the most recent temporary undertaking. Although this appears to work well within a single country, the situation becomes more complicated and unclear when radiation workers work as contractors in different countries: the mutual acknowledgement of official and operational dose records from foreign countries, the interpretation and application of different dose limits or constraints, and the updating of national dose records with doses received abroad are often not explicitly regulated in national regulations.

The EGOE felt it useful to include the radiation protection aspects of cross-border travelling (migrant) nuclear workers into the case study as this topic is also recognised and receiving attention in international organisations. For the countries of the European Union, the Working Group on European Radiation Passbook and Outside Workers (WG 1) of the Heads of European Radiological Protection Competent Authorities (HERCA) has proposed a harmonised European Radiation Passbook template which is recommended to be used in European member states. The group has also launched a pilot project with the perspective of developing a radiation passbook information system based on electronic data exchange between EU member states. The IAEA is currently updating a technical document on outside workers and held a Technical Meeting on Occupational Radiation

Protection for Outside Workers in November 2011. Although the idea of a passbook is in use within OECD/NEA countries, it does have its drawbacks, and is probably not the final answer to this problem. For example, workers may lose their passbooks, some may have several passbooks, some quantities and terms used in passbooks may have somewhat different meanings in different countries, etc. However, it is recognised as a step toward an international system, probably electronic, that could eventually address all of these issues. This issue is gaining in urgency because of the substantial increase in the movement of skilled workers between power plants within a given country, within the OECD/NEA, and world wide.

European Radiation Passbook

Within the European Union occupational radiation protection is regulated by European Council Directive 96/29/Euratom with the intention of harmonisation between the EU member states. The European Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionising radiation during their activities in controlled areas formulates particular requirements for the protection of outside workers and explicitly states that the radiological monitoring system of outside workers should provide equivalent protection to that for workers employed on a permanent basis by the operator. In fact the existing directive requires "a network and/or individual document" to guarantee the monitoring of outside workers, while the future directive stipulates "a data system for individual radiological monitoring".

The legal situation for outside workers in the EU appears to be relatively homogeneous. Yet, there remain many differences between the member states in their practical implementation of these Directives, as well as additional specifics in national legal requirements. The numerous languages spoken in Europe further complicate the situation regarding the acknowledgement of required documents for workers crossing national boundaries.

In order to solve the problems involved with the mutual acknowledgement of dose documentation which range from defined electronic dose data records to loose paper documents, etc., for outside workers who work in different European countries an important step has been taken in the European Union. HERCA, a network of the chief regulatory authorities of 31 European countries, initiated a harmonised work that proposes a passbook model with a guidance document. This model is to be considered as an example template, not as a fixed model. But any passbook that is developed should at least contain the mandatory fields given in the passbook model and is recommended to be used by all outside workers in the EU member states in the future. It is to be issued by national regulatory authorities or, with regulators' approval, by other responsible institutions. The terminology used is coherent with the presently revised European Basic Safety Standards Directive (the Euratom BSS, latest draft of 29/09/2011). The content of the passbook is printed in the respective national language plus in English. It is laid out to provide all information necessary to attain access to a controlled area in a member state. It contains mandatory data fields (in black) for the information required in every member state and optional data fields (in grey) for additional information that may also be necessary in some of the member states. The radiation passbook consists of eight sections:

- *Section 1*: Details of the radiation worker (normally to be completed by the company or institution designated by the competent authority to issue the radiation passbook).
- *Section 2*: Issuing details of the radiation passbook (to be completed by the entity issuing the radiation passbook).
- *Section 3*: General information (any information needed by a foreign undertaking to interpret the conditions applying to this worker, depending on the nationality of his or her employer).

- *Section 4*: Current employer (to be completed by the employer of the outside worker).
- *Section 5*: Medical surveillance (to be completed by the approved medical practitioner or approved occupational health service acting for the employer).
- *Section 6*: Official dose record up to the radiation passbook issue date (to be completed by the entity issuing the radiation passbook).
- *Section 7*: Operational dose in the undertaking's controlled area(s) (mSv) (an estimate of any dose received by the outside worker, to be completed by the undertaking after the end of any activity in the undertaking's controlled area).
- *Section 8*: Information regarding training in radiological protection (to be completed by the person or entity responsible for the training).

In addition to the radiation passbook, a guidance document is provided to support the implementation and practical use of the passbook. This document addresses regulatory bodies, the employers of the outside workers and the undertakings with the controlled areas. The mentioned document includes:

- The responsibilities of employer and undertaking regarding the radiological protection of outside workers against the risk of ionising radiation.
- Aspects to be fixed by contractual agreement between employer and undertaking regarding the employment of an outside worker.
- Roles of employer and undertaking regarding the radiation passbook.
- Implementation of a radiation passbook:
  - purpose of the radiation passbook;
  - medium used for the radiation passbook;
  - who should be given a radiation passbook;
  - language and terminology;
  - issuing body of the radiation passbook;
  - procedure for issuing the radiation passbook.
- Data to include in the radiation passbook.

As an example, the European Radiation Passbook provides a harmonised format, terminology and data structure for all EU member states and allows the member states to document additional, country-specific information. Since it is both harmonised for international use within the EU and flexible for national specifics, the passbook is of practical value for outside workers working internationally. HERCA encourages non-European countries to make use of this radiation passbook template.

The European Radiation Passbook was approved by the HERCA Board in May 2012. The passbook's associated guidance document was approved as an optional document by the HERCA Board on 30 October 2012. It will be revised after the new European Basic Safety Standards Directive is published. Both the *HERCA Radiation Passbook Model (Version 2)* and *Guidance on the Implementation of a Radiation Passbook and its Practical Use* can be downloaded from the HERCA website at www.herca.org/herca_news.asp?newsID=26.

The European Radiation Passbook template is currently designed as a paper booklet. However, the revised European Basic Safety Standards Directive will commit all EU member states to implement a national data system that registers obligatory data about individual radiological monitoring of all radiation workers. In practice, these systems will be electronic. It is therefore consequent to consider the possibilities of future electronic data exchange between the involved institutions of outside workers (i.e. undertaking,

employer, regulatory body). With this in mind, the HERCA WG 1 is conducting a pilot study to develop an electronic, web-based system to enable international data exchange of radiation passbook data between interested EU member states.

Activities on occupational radiation protection of outside workers at the IAEA

The importance of occupational radiation protection's focus on outside workers was highlighted in the IAEA after the publication of the International Basic Safety Standards (BSS) for Protection against Ionising Radiation and for the Safety of Radiation Sources in 1996. It was recognised that specific guidance on the occupational radiation protection of outside workers would be beneficial. A draft safety report was prepared in 2003 to provide guidance for the application of the requirements in BSS to outside workers after a consultants' meeting in 2002. The guidance material covers the issues associated with the protection of outside workers, such as the allocation of the management responsibilities, the provision of suitable dosimetry arrangements and health surveillance, the adequacy of training, etc.

Occupational radiation protection for outside workers is also specified in the revised International Basic Safety Standards (IAEA, 2011b). There are two requirements which have a direct link to this issue, as follows:

- *Requirement 22*: "Compliance by workers, 3.83 (d), it is indicated that workers shall provide to the employer, registrant or licensee such information on their past and present work that is relevant for ensuring effective and comprehensive protection and safety for themselves and others."
- *Requirement 23*: "Co-operation between employers and registrants and licensees, 3.87, it is indicated that the registrant or the licensee responsible for the source or the exposure shall: a) obtain from the employers, including self-employed individuals, the previous occupational exposure history of workers and any other necessary information; b) provide appropriate information to the employer, including any available information relevant for compliance with the requirements of these standards that the employer requests; c) provide both the worker and the employer with the relevant exposure records."

The issue of radiation protection of outside workers will also be included in the Safety Guide on Occupational Radiation Protection which is currently under development by the IAEA.

The Technical Meeting on "Development of Guidance Material on the Management of the Radiation Protection Programme for Outside Workers" was held at the IAEA on 21-24 November 2011. Representatives of eleven member states and three international organisations attended the meeting. The roundtable discussions addressed among other things the allocation of responsibilities and specific radiation protection issues such as optimisation, limitation, individual monitoring, health surveillance and medical follow-up, training, and passbook. It was suggested that the main focus of the guidance material would be to address the communication and co-operation between relevant parties for the operational radiation protection of outside workers in applying the relevant requirements of the new BSS. The mechanisms for information exchange were added to the scope. A consultant meeting is planned in 2013 to finalise the draft guidance material.

Survey on trans-boundary outside workers

The EGOE conducted a survey on national practices for international outside workers in 2011 among the CRPPH members to obtain an overview of how countries handle the situation when a radiation worker from one country works temporarily in another country, in particular about the required dose information, dose limits and their

interpretation, documentation and registration of doses received abroad. It was advised to keep the survey short and specific to identify the CRPPH member country policies, and implementation and communication procedures of the origin and destination countries for travelling outside workers.

The EGOE received completed questionnaires from 12 countries: Canada, Belgium, Denmark, Finland, France, Germany, Poland, Romania, Spain, Sweden, Turkey, and the United States. As most of the responses came from European Union member states, the results of the survey mostly reflect European practices. However, even amongst the EU countries, significant differences were found. Specific responses to the survey are located in Annex 1 of this report.

The results were in agreement that outside workers, whether from the same country or from other countries are subject to the same regulatory rules as those applied to the permanent workers at the facility. Stated differently, once inside the facility, there is no regulatory distinction between a permanent worker and a temporary outside worker. This means that the dose limits in the jurisdiction of the undertaking's country are to be applied, no matter what limits an outside worker is bound to in his or her home country. The responses to the questionnaire did not indicate what action is taken, if any, when limits and other requirements differed between the home and guest countries. In most countries where there are uniform regulatory requirements and undertakings (or licensees) have efficient ALARA practices, workers rarely breach regulatory dose limits. This applies in particular for the nuclear industry; but it may not be the case everywhere. An example where dose limits may be approached is the case of workers that have a highly specialised skill. Such workers are one of the drivers of worker movements, since their skills are in demand internationally, and this in turn may lead to annual exposures that approach certain limits, either in the country of their permanent employment or in the host country.

Another issue that is often encountered with outside workers is that most are monitored using two types of dosimetry: real time, active dosimetry that provides a running estimate of the worker's dose, and passive dosimetry that provides the official dose of record. Passive dosimeter results normally become available on a periodic basis, when the dosimeters are processed by the dosimetry service, often once every 1-3 months. Because of this system, a worker arriving at a temporary work site may not have an up-to-date dose record based on official dosimetry, but will have the data from active monitoring. Issues are then raised regarding the acceptability of such records, and whether they can be used as a basis for starting work at the temporary site. Questions such as the reliability of the active dosimetry, any applicable standards of accuracy criteria for such dosimeters, etc., will need to be addressed.

An important issue that came out of the questionnaire was highlighted by the responses from the EU countries. In seven EU countries, annual dose limits are calculated on the basis of the calendar year and in three on a rolling twelve-month period. Further, in addition to a 20 mSv/year limit, there also exist (but not in all member states) limitations expressed as 100 mSv/5year including 50 mSv/year limit and in Germany and Austria an additional occupational lifetime dose limit of 400 mSv. Challenges associated within these differences were not examined in the questionnaire.

It was also noted in the responses that employers are required to periodically report dose data for their workers to a national regulatory authority or its equivalent. Details on whether the temporary employer or the permanent one is to report that information, which group is to provide the dosimetry of record to the worker, and how to avoid duplication and multiple reporting were not examined in this questionnaire. The responses did show, however, that at least for the EU countries, the radiation passbook serves not merely as a document for operational dose control but also as the central document to carry the radiation protection information of an outside worker.

Questions and possible links to the survey

The following set of questions reflects discussions during EGOE meetings. The answers are mainly linked to the responses given in the survey. The questions are not claimed to be sufficient, in particular as the survey was restricted to only a few questions and the responses may be somewhat Eurocentric. They however raise the visibility of radiation protection issues for outside workers who work in controlled areas of foreign countries.

1) *When a worker enters a plant site, who is responsible for his or her exposure and safety – the site licensee, the host national government, or the worker's employer?*

   Dealing with the responsibility, Finland indicates that the employer of the worker and the licensee are in charge of assuring that the worker is fit for the radiation work. The French practice is a part of the labour code which states that "an employer who transfers temporarily workers on the French territory or an independent worker coming on the French territory for working shall be subject to all the requirements of the labour code." The undertaking has responsibility with the employer of the outside worker to check dose records. However, concerning workers transferred by an employer from another country, there is no specific requirement in the French regulations on the way both the employer of the outside worker and the undertaking exchange the dose data of the workers. In Belgium, the employer of the worker is responsible for providing the official dose records to the undertaking. In addition, all relevant dose data of the worker ("official" doses of previous and current years and any available doses from operational dosimetry) will be made accessible online to the undertaking by the employer once the contract between the employer and the undertaking is signed (presently, the system is technically under development). In Germany, the regulatory body requires exposure data from operational dosimetry of each nuclear installation (including NPPs) to which the outside worker had access. Both official and operational dose data are accepted in determining the exposure of the outside worker for the period before entering the current controlled area. All official dosimeters are non-electronic and evaluated by official dosimetry services on a monthly basis. As a consequence, official dose data for the current and previous month are usually not yet available. All this information is documented in the German radiation passbook. In the case of workers arriving from foreign countries, this information will be requested too. Compliance of dose records from foreign countries with the requirements of the German radiation passbook will be assessed by the regulatory body of the NPP. In Canada, with regard to the licensees' obligations, the regulations stipulates that every licensee shall train the workers to carry on the licensed activity and the licensee takes all reasonable precautions to protect the environment and the health and safety of persons. In addition, with regard to the obligations of workers, Canadian regulations stipulate that every worker shall use equipment, devices, facilities, and clothing for protecting the environment or the health and safety of persons, or for determining doses of radiation/dose rates in a responsible and reasonable manner.

   The draft of the new EU-BSS states that the undertaking is to be responsible for all outside worker qualification and radiation protection aspects directly related to the specificities of the task or the workplace. This includes in particular checking documented medical fitness and specific training, personal protective equipment, appropriate individual exposure monitoring, and operational dosimetric monitoring. Details are to be fixed by contractual agreement between undertaking and employer.

2) *Does the answer to No. 1) depend on whether the worker is employed by an outside company or is an independent worker?*

   There is no information about this issue in the responses to the survey. However, an independent worker is usually regarded as a self-employed contractor with equivalent requirements as other outside companies.

3) *If the employer of the worker (licensee in home country) and the site (undertaking in foreign country) have different national restrictions, would the more conservative restrictions apply? Who would make such a requirement, and is the site obliged to abide?*

   There is no information about this issue in the responses to the survey. The only generally applicable answer is that the regulatory restrictions of the site in the foreign country are to be met for both their own personnel and the outside workers, wherever they come from. The application of the more conservative restrictions appear plausible from a radiation protection view and this is also the case within the EU. Yet, it is primarily a question of specific jurisprudence, and thus it depends on the particular national law.

4) *Do the national regulations of the worker's home country apply or have any relevance when he or she is working outside the country? Does it matter whether the worker is working for a home company or is self-employed?*

   If this question is assessed as the application of dose limits, which is generally a part of the national regulation, all participating countries provided information for No. 3). However, there is no information for the distinction.

5) *If the regulations of the site country require providers of passive dosimetry to be accredited, does it matter if the worker's home country accepts services that are not accredited? Would the dose history still be acceptable?*

   Only Turkey requires extracts from accredited dosimetry services or central dose registers. In Canada, it is not required that foreign dose records come from accredited dosimetry services, but it is desirable and recommended. However, all foreign dose records received will be filed with the National Dose Registry (NDR) (at the worker's request) and flagged as foreign dose records. In addition, dosimetry services in Canada are licensed by the CNSC and therefore other accreditations are not recognised under the regulations. In Finland, exposure data from a passbook or from an accredited dosimetry service is required. In France, there is no specific requirement for the exchange of dose records. In Spain and Germany, a dosimetry passbook is required in accordance with EU legislation.

6) *Some (if not all) countries require the worker to receive respirator training before being allowed to work in potentially airborne radioactivity areas. Would the site require such training, or would it accept the training provided by the home country? On what basis can a site accept such training?*

   Only Germany requires information on expiration date and status on the approval to work with respiratory systems (required, if the worker is to work with respiratory systems) as a part of the transfer of necessary information to the occupational dosimetry service of the NPP. However, dealing with the RP training (in a general sense), Canada indicates that the RP programmes implemented at licensed facilities do not differentiate between permanent or outside workers, therefore any work requirements will apply uniformly to all workers. The information required under the RP programmes includes medical records, radiation protection training and respiratory protection training. In Finland, RP training can be considered to be qualified for both Finnish NPPs, if the plant-specific characteristics and differences have been taken into account in connection with training. For example, it is sufficient that written material be handed out to workers. On the same basis, RP training in Sweden can also be approved at Finnish NPPs. In Sweden,

education/training records could be accepted if performed and documented in a reliable way (e.g. co-operation with Finland). This information, however can never replace the needed local information (e.g. about the premises, alarms, local safety rules, and other needed local RP and safety information). In Turkey, the licensee is responsible for medical surveillance, training and the other operational radiation protection issues. Spain recalls the passbook which should include information on RP training.

7) *Sites also require medical certification that appropriate workers are fit to wear a respirator. Would the site accept such certification from a doctor in the home country?*

Referring to answers for No. 6), medical records are required in all participating countries. In Finland, the licensee shall also ensure that the medical surveillance of an external worker has been organised according to the Radiation Act and Decree. The licensee shall keep a record of the performed medical examinations of Category A workers. In France, a worker can be assigned to work exposing him or her to ionising radiation only after having undergone a medical examination by the occupational health physician and on condition that the fitness data sheet drawn up certifies that the worker has no medical contraindication for such work. In Sweden, medical records could be accepted if performed and documented in a reliable way (e.g. co-operation with Finland). In Turkey, the licensee is responsible for medical surveillance. In Romania, medical records are required and in case of missing information, the medical examination needs to be performed by the operator. In Poland, the medical decision on the admission to work in conditions of professional exposure to external radiation/internal contamination is made by an authorised physician. Medical recommendations on contraindications related to the use of the measures protecting the respiratory system against radioactive contamination are also made by an authorised physician.

8) *If a European worker has an annual dose to date of say 10 mSv and goes to work in a country with a dose limit of >20 mSv/year, is the host site obliged to observe the European 20 mSv limit? Does this change depending on whether the worker is self-employed or works for a contractor organisation in a country with a 20 mSv limit?*

Companies in countries with dose limits of >20 mSv/year are not required to follow the EU 20 mSv annual limit. However, they should be aware that an employee of an EU contractor company will be restricted in his or her home country if the worker's annual dose exceeds 20 mSv. If the host site company is willing to comply with EU dose limits, it may be better able to develop acceptable contractual arrangements with business partners (employers of outside workers) from EU countries. Therefore, it is a business decision of the host site company in developing agreements between the operator and the contractor.

9) *Is the worker violating any law if he or she gets a total legal dose of 40 mSv in a host country and then goes back to his or her home country with a 20 mSv/year limit, assuming the worker does not seek employment there for the rest of the year?*

There is no information about this issue in the responses to the survey. If and how previous doses are balanced is primarily a question of the specific national law in the worker's home country. The employer should clear this issue with its regulatory body. Based on this, operator and employer should discuss anticipated doses in advance.

10) *What mechanism is recommended for a host site (e.g. in the United States) to report the worker's dose to his or her employer, if the worker is employed by a foreign company? What if the worker is self-employed? What is there to prevent the worker from just not mentioning the host site employment? Note that dosimetry providers in the US do not report the result of dosimetry monitoring to anyone other than the site operator (i.e. the licensee). The licensee is obliged to report the doses to the worker and then to the US government at the end of the calendar year.*

There is no specific information for this question from the survey.

Dose reporting procedures should be fixed in a contractual agreement between the host site and the foreign company or self-employed individual. Concealing a previous employment cannot be avoided in any case, but it can be impaired, e.g. by prompt dose entries in the radiation passbook and the demand for official dosimetry results from the dosimetry service of the home country. Within the European Union, Council Directive 90/641/Euratom on the operational protection of outside workers exposed to the risk of ionising radiation during their activities in controlled areas (EU, 1990) needs to be followed for work as an outside worker (including self-employment). In addition, calendar year dose records are applied in Canada, Finland, Sweden, Romania, Spain, Germany, and Poland.

11) *If the worker works again in his or her home country, what mechanism or procedure would the employer follow to obtain the worker's past exposure history?*

No. 7) is about a worker who worked and received occupational dose in another country and returns to the original country. All participating countries provided their national practices in their responses to this question.

12) *What if different countries use different factors to calculate the equivalent or effective doses (e.g. radiation and tissue weighting factors, remainder organs, etc.)? Would these be considered directly additive? Would adjustments be necessary or required?*

This is beyond the scope of the survey. In practice such problems are probably very rare and occur only if the dose calculation factors are revealed, which is normally not the case as usually only the dose values are reported. One may deal with this problem in detail as an individual case if a worker's dose is approaching one of the dose limits (or constraints).

Final remarks

National regulations about radiation protection serve national needs and end at national borders. Thus, regulations and monitoring practices often differ between the various countries, although generally acknowledged ICRP recommendations exist. International outside workers operate therefore in a heterogenic legal environment and have to cope with regulatory inconsistencies and conflicts among the different countries involved. The European Union has taken important steps towards harmonisation both by the current revision of the EU-BSS and by the recommendation of the harmonised European Radiation Passbook. On a global level the IAEA is working on a Safety Report on Radiation Protection of Itinerant Workers. In spite of these activities it cannot be expected that international agreements on all outside worker issues will be formally established in the near future.

Contractual agreements between the site and the outside worker's employer are important legal instruments to cover non-matching radiation protection regulations of different involved countries: they stipulate where the responsibilities of the involved contract partners begin, what they consist of and when they end, and they allow adapting a worker's contract to the different legal requirements of the countries involved. In particular about dose recording and reporting, it is the outside worker who is the only link concerning the work he or she does in the various countries. This implies that a

worker should not only rely on the care of undertakings, employers and regulators. The worker should be aware of the personal responsibility which implies the duty to provide for an up-to-date dose history, complete documentation of radiation-protection-relevant certificates, and last but not least to keep exposures ALARA.

3. INTEGRATION OF RISK MANAGEMENT AT NUCLEAR POWER PLANTS

Facilities using radioactive materials or radiation-producing machines are common across many industries. Such facilities are ideally managed with a strong emphasis on worker safety and that of the public, to guard against all kinds of contributors to risk, including radiological, industrial, chemical, and others. The concern for safety starts from facility inception, through design, construction, operation, and finally decommissioning. At some facilities, the safety functions are fragmented, with different types of contributors to risk being the purview of different departments within the facility. The approach to safety now recommended places emphasis on co-ordinating these different safety functions to optimise overall safety using a coherent system of planning of equipment and facilities, and implementation of work activities. This is rather difficult to achieve, partly because the risks from different contributors to risk are often expressed using different and sometimes incompatible measures of risk, and partly because risk specialists tend to be specialised in a particular type of risk and are not as familiar with the other types of risk-producing agents that may co-exist with those with which they deal. The awareness of different types of risk, and the emphasis on careful planning and execution to optimise safety, is an important element of a safety culture. The statements above are oriented toward facility operators, but it is also true that some of those same elements of fragmentation may be found as the applicable regulators carry out their mandated roles of authorising and overseeing facility operations.

The concept of having a robust safety culture is endorsed by organisations such as the IAEA, WANO, and INPO. The OECD/NEA has defined safety culture as "that assembly of characteristics and attributes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues received the attention warranted by their significance" (OECD/NEA, 1999). In its Action Plan on Nuclear Safety,[1] the IAEA calls out an action to "strengthen the effectiveness of operational organisations with respect to nuclear safety", with member states (governments) ensuring necessary improvements in safety culture (IAEA, 2011a).

National regulations and regulatory guidance for the design and operations of nuclear facilities should (in part):

- "demonstrate an integration and coherence of regulation across all governmental agencies (nationally and where feasible, internationally);
- be risk-informed and performance-based, to maintain a proportionality between risk significance and regulatory burden;
- include processes for regulator/licensees dialogue to help to maintain regulatory accountability for appropriate regulatory focus on worker and public health and safety." (OECD/NEA, 2010)

In that way, the regulations and guidance will assist in the development and maintenance of a robust safety culture that addresses the several contributors to risk in a coherent manner.

1. The Action Plan was approved by the IAEA Board of Governors on 13 September 2011, as endorsed by the IAEA General Conference during its 55th regular session on 22 September 2011.

As stated by a nuclear industry executive during the 2007 ISOE International ALARA Symposium, "safety is the continuous first issue. If there is even the slightest perception of a lack of total commitment to nuclear, radiological, and industrial safety, there will be no future for nuclear energy." (Palms, 2007) That statement is a reflection of industry intent to create and maintain a safety culture as a critical component of industry operations. The strong, visible support of corporate officers and senior facility managers is necessary for the existence of a robust safety culture.

This document aims to provide comprehensive information regarding the establishment or maintenance of a robust safety culture. However, introductory comments relating to an effective safety culture may help the reader recognise that the term "radiological safety", as important as it is, is part of a safety programme that also embraces nuclear safety and industrial safety. Indeed, the term "environmental safety" is sometimes added to descriptions of a safety culture, to reflect not only protection of the members of the public (and by logical extension, the non-human environment) via the necessary attention to safety and security of the reactor core (or other appropriate radiation source) but also protection of the environment from any detriment caused by radiological and non-radiological effluents from the facility.

It is in the broad context of safety that radiation safety plays an important role. For the management and staff of a nuclear power facility (or other facility using radioactive materials or radiation-producing machines), the multiple components of risk to the workers and to members of the public are to be considered on an ongoing basis. This consideration of contributors to risk is also performed by the regulator(s) providing the legislated authorisation and oversight roles for such a facility. As described in the next section, regulators generally specialise in their area of legal mandate, and different agencies may be responsible for different types of risk agents. There are often efforts at co-ordination, but co-ordination is sometimes not a requirement.

Moving toward coherence and integration

In this report, management is discussed of all relevant facility-related risks to workers at the facility and to members of the public (and the non-human environment) around the facility. A key point of the report is to promote management of all of those relevant risks simultaneously, proportionally to the magnitude of the risks from the contributors to risk, and considering the potential for interactions between the risks or actions planned to mitigate the risks. Various terms may be used to describe such a process, for example, "holistic", "optimised", "co-ordinated", "integrated", and "global". For the purposes of this report, the term "integrated" has been used, not because the term is necessarily better than one of the others, but hopefully to avoid confusion when multiple terms are used to describe one process.

It is not uncommon that national and international standards-setting organisations or regulators are limited via their charter to consider primarily or even exclusively a singular contributor to risk to workers or members of the public. Even when such an organisation or regulator is chartered to consider multiple contributors, a singular contributor may be primarily addressed by one portion of the organisation, while another singular contributor may be primarily addressed by a second portion. Even when this is the case, however, nearly all facilities are regulated by multiple agencies, each applying its own set of rules and considerations to risk contributors within its jurisdiction. Such an approach has advantages, for example, in ensuring that individuals addressing a contributor to risk have the appropriate education and experience to comprehensively assess that contributor. The potential disadvantage of such an approach is that assessments of the contributors are performed with a singular focus on each contributor but not necessarily with a focus adequate to address all contributors together and proportionally to the magnitude of the potential risk of each contributor to the workers or members of the public. It is recommended that regulatory agencies ensure that: *i*) the

operator of the facility ensures that specialists who address specific, limited risk contributors within their area of responsibility also participate in joint sessions with other safety specialists on site to ensure a co-ordinated approach to safety; *ii*) the same concept of joint sessions is used whenever practicable by the relevant regulatory specialists.

In the report of an IAEA committee, a committee member made the observation that "there was still a divorce between the occupational health and safety community and the radiation protection community." (IAEA, 2011c) It is clear that the speaker was referring to the need for a better link between those communities in addressing risks to workers. Notably, the above quotation is taken from the discussion related to an action item stated as follows:

> *The IAEA and ILO are to collaborate in devising strategies for achieving a better understanding between radiation protection practitioners on one hand and occupational health and safety practitioners on the other and for developing coherent approaches to safety in the workplace*. (IAEA, 2011c)

The IAEA committee has endorsed development of an inter-agency (IAEA, ILO, and WHO) guidance document on "developing a coherent approach to radiation and other risks factors at work place." The committee also recommended that other actions be taken, to provide forums and other means to promote coherent and integrated approaches to risk assessment and reduction. For the purposes of the document presented here, note is made that the focus of this IAEA committee was on the population of workers; therefore, nuclear and environmental safety deliberations as related to members of the public were not considered by this committee.

The European Commission enacted Council Directive 89/391/EEC to encourage improvements to workplace safety and health (EU, 1989). The directive is legally binding for the European Union member states; it applies to multiple contributors to workplace risk and contains general principles concerning the prevention or reduction of workplace risks. The emphasis is to ensure measures are taken for protection of workers, including the provision of information, training, and necessary organisation and means. The measures are to include development of a coherent overall policy to address "the influence of factors related to the working environment". The work methods are to be integrated into all activities and management levels. Consultation with workers to discuss workplace safety situations is expected. As with the IAEA committee, the European Council Directive is focused on worker protection.

The comments of another committee, this one established by the Information System on Occupational Exposure (ISOE), expressed the following:

> *One aspect of work management that has always been somewhat difficult to address is that of risk transfers. Plant modifications undertaken for nuclear safety reasons, or to reduce emissions for public or environmental protection, are, in effect, transferring risk from the public and the environment to workers, in the form of the worker exposure needed to perform the work. However, the ICRP has not provided guidance with regard to the types of considerations that should be balanced in making such judgments. Such considerations are equally related to the justification of the work and to the optimisation of the work that is going to be performed*. (OECD/NEA, 2005)

This comment is not included in the report presented here as a negative comment on the work of the ICRP, but rather is included to note that in developing a coherent and integrated approach to total risk management for a facility such as a nuclear power plant, both risks to workers and members of the public need to be considered, and those risks cannot be considered to be independent factors during that consideration.

The EGOE Case Study 2 report, wherein factors of total risk management are discussed, evaluates potential applications of dose constraints for workers exposed by radiation sources (OECD/NEA, 2011). The EGOE report notes that the ICRP, in Publication 101,

explains that protection options for workers are to be broadly and holistically assessed. In addition, the report indicates that guidance documents, from whatever appropriate sources, could be enhanced "to better and more explicitly recognise the need and current reality that NPP operators balance and optimise all relevant risks to workers (and to the facility) including, for example, heat stress, other elements of industrial safety, nuclear safety and environmental safety (including but not limited to public dose control)." (OECD/NEA, 2011) As with the work of the IAEA committee described above, Case Study 2 primarily addresses risks to workers and states that "occupational radiation protection is not practiced in a vacuum with exposure to ionising radiation as the overriding risk" but rather radiation protection is to be considered along with "industrial safety, nuclear safety, environmental safety and facility reliability in production of electricity" for public use. This is true for the facility operator and the regulator(s) of the facility.

In a presentation at an ISOE ALARA symposium, it was indicated that there are possible mutual benefits for radiation protection and for other safety programmes in evaluating the processes used in those programmes and especially how the process of optimisation as relates to occupational radiation protection may reduce risks due to other classical occupational risk factors (Deboodt, 2000). The author indeed states that "the ALARA approach has led to a general increase of the safety level of the nuclear sector. This is mainly due to the structured, coherent and self-critical approach which underlies the ALARA principle." He goes on to say that "the extension of the ALARA approach to other industrial risks should be a good step for developing another base for discussion with the public" about the complexity of factors affecting decisions which have to be made and the approaches to communicate how those complexities are addressed.

The author notes, as have others as described above, that "sometimes one has the feeling that there is an 'artificial' distinction between the 'radiological' language and the 'non-radiological' one."

The author describes a seemingly (radiation-protection-principles) ALARA-centric approach to coherently addressing various risk contributors. Whether that approach is taken or whether an approach that may be said to be more work-management-based is taken, a likely valid point is made in describing that various risk contributors may be addressed together, with the objective of reducing multiple risks with those common actions.

Key points

- The desirability of taking an integrated approach to the mitigation of the various radiological and non-radiological risk contributors has been recognised for a number of years. The issues were broadly discussed in 2000 at the 4th Workshop of the European ALARA Network on "Managing of Occupational Radiological and Non-radiological Risks".[2]
- Evaluation of multiple risk contributors and development of plans for risk mitigation require management attention. This is especially true if transfers of risk or interactions between risks may be involved. Senior facility managers must ensure that they strongly and continually demand consideration of the relevant risks and the bridging of any communication gaps in making balanced decisions involving multiple contributors to risk. Regulatory personnel should ensure both that facility managers are executing a reasonable process for considering the relevant risk factors in an integrated fashion in operations decision making and also that regulatory guidance encourages such an integrated assessment.
- Effective processes for integrated risk management will always remain in development, because: i) society's perspectives on risk are dynamic; ii) scientific

2. www.eu-alara.net/index.php/workshops-mainmenu-38/24-workshops/56-ean4.html.

understanding of risks and their interactions improve with time; *iii)* techniques for work performance evolve with time and technology. Facility operators and regulators should remain aware of emerging changes regarding these factors and should encourage reasonable continuing efforts to enhance scientific understanding and work-performance techniques.

Describing commonalities for purposes of risk reduction

The establishment of a robust safety culture at a facility (and within the relevant regulatory authority) is a critical component of risk reduction for a facility. Various documents address the overall concept of establishing a safety culture in facility design and operation, and these documents will not be discussed in this report. The objective here is to mention that absent a robust safety culture, risk reduction is much more difficult to accomplish. Presence of a robust safety culture leads to involvement of all facility workers (craft workers and management alike) in developing ideas for risk reduction, to effective oversight by regulators assessing and commenting on plans for risk reduction, and to effective execution of authorised risk reduction techniques.

Presuming the existence of a robust safety culture, workers are encouraged and empowered "to contribute to optimisation of protection, broadly through work planning and management." (OECD/NEA, 2005) Experience and involvement of workers is a basis through which work efficiencies are obtained, "many more aspects of worker health and safety than simply radiation protection" may be considered, and aspects related to nuclear and environmental safety may also be considered (OECD/NEA, 2005). Examples may be lower doses, fewer industrial safety incidents, improved equipment reliability and maintainability, and more efficient use of resources.

The objectives of work management may be achieved by several approaches. The focus is to consider relevant aspects of work selection, work planning, work scheduling, work preparation, work implementation, and work assessment (with feedback to ensure continuous process improvement). A document which addresses a work management approach in detail may be found in OECD/NEA (2009).

As stated in that report, use of "a coherent and comprehensive work management approach, in addition to contributing to good radiation protection, also facilitates safe and economic plant operation". Work management is a comprehensive methodology which stresses the importance of managing jobs completely from planning to follow-up using a multi-disciplinary team approach which involves all relevant stakeholders. If properly applied, work management will lead to a reduction of occupational exposures in an ALARA approach. Thus, the goals of reducing cost as well as classical safety risks and of minimising the time required for an outage can often be simultaneously fulfilled. "By engaging the worker in the [phases of planning of the] task being performed, the worker is more likely to be motivated to perform the job to the best of his/her abilities, and this will be reflected in lower dose jobs as well as in higher job quality." (OECD/NEA, 2009)

Examples of common elements to reduce risk across multiple factors include the following. The list is not intended to be all inclusive, but rather to illustrate that workers from many different disciplines may contribute to improved radiation protection, while other worker and public protection considerations are simultaneously addressed. At well-managed facilities, the topics relevant to risk elimination or reduction are discussed by the workers and their supervision, and plans are developed to timely take the reasonably appropriate steps for risk elimination or risk reduction:

- effectively designed ventilation and filtration systems;
- effectively designed work platforms, lighting, power supplies, work area lay-outs;
- effective fluids and water chemistry control;

- use of materials which are able to be easily decontaminated;
- effectively designed access and egress to plant areas and equipment;
- use of equipment which is reliable and easily maintained;
- effectively designed shielding and remote operators for equipment in higher risk areas;
- effective procedures for fuel integrity protection;
- effective use of risk assessment and risk mitigation planning;
- effective use of human error reduction techniques;
- involvement of all relevant disciplines in job planning, scheduling, and preparation;
- use of the least hazardous chemicals and other agents consistent with high quality job performance;
- effectively written procedures;
- effective selection of tools appropriate for job implementation;
- effective selection of crew size and crew composition;
- effective selection of protective clothing appropriate to the relevant risk agents for the job;
- effective foreign materials exclusion programme;
- effective training and qualification of craft workers to support high quality job implementation;
- effective use of management review committees, especially those evaluating risk assessment and risk mitigation planning;
- effective use of pre-job briefings for affected workers and work groups;
- effective use of in-job communications techniques among all relevant work groups;
- effective use of post-job assessment, corrective (and enhancement) action development, and feedback to job planning.

The reader may be expected to find helpful information in both OECD/NEA (2010) and OECD/NEA (2009), addressing plant design and work management, respectively.

Traditionally, radiation protection was based on appropriate consideration of time, distance, and shielding. Reduction of the magnitude of the radiation fields via source term reduction techniques is also considered to be of importance. As shown in the list above (and certainly as described in the two OECD/NEA documents cited above as references), by virtue of effective work management in design and in operations, each of the radiation protection elements is addressed. Notably, other risk contributors to worker health and safety, and risk contributors to members of the public and the overall environment, are also addressed, such that overall risk to workers and members of the public are reduced via the use of effective work management in design and operations, resultant from existence of a robust safety culture.

Key points

- The work management process may be used effectively in integrated risk management. Multi-disciplinary involvement in work selection, work planning,

work scheduling, and work execution (e.g. pre-job briefings and communications during work performance) helps ensure identification and consideration of all relevant risk contributors.

- Use of a process to ensure work is performed as safely as reasonably achievable (ASARA) may be modelled on the ALARA process used regarding radiological risks. The ALARA process is a multi-disciplinary, structured, self-critical approach that is also iterative and ongoing as appropriate to the work.

Recognising trade-offs and balances

Realistically, most documents that have described establishment and maintenance of an effective safety culture at NPPs were written with a focus on nuclear reactor safety. A primary consideration was the prevention of nuclear accidents or other events which could potentially jeopardise the integrity of the fuel, the reactor pressure boundary, or the reactor containment. In managing emergent operational situations, the licensee (facility operator) assesses the risks to nuclear safety and acts appropriately to mitigate those risks; the regulator may independently assess risks and act to ensure potential safety-jeopardising risks are indeed mitigated. A common action for an operator is to plan for corrective maintenance on equipment important to nuclear safety that is assessed to need such maintenance for ensuring reliability of that equipment. (Other actions may, for example, be placing additional equipment into service, replacing equipment that is deemed to be non-repairable, or deferring elective maintenance on non-critical equipment to support operations of equipment directly tied to assurance of plant safety.) The facility operator uses a process that results in informed nuclear-safety-conscious judgments that result in actions by workers to maintain equipment (or place equipment in service, and so on); that is, a judgment is reached that a certain set of actions is justified to maintain nuclear safety risks at a level which is acceptable to the facility operator and which meets the mandates of the regulator. The workers are impacted by the decision making, in that their action in the plant environment is now needed, on a potentially expedited basis, to ensure equipment important to safety is working as desired.

For those more frequently encountered periods when emergent conditions are not an issue to be addressed, facility operators use plant and industry experience to determine when to perform routine or preventive maintenance and/or perform routine inspections on equipment important to nuclear safety to ensure system reliability. Regulators may also specify performance-based maintenance or plant-condition-based inspection on equipment important to nuclear safety. Operators then have some level of flexibility to schedule such maintenance or inspections at times when more optimal industrial or radiological safety conditions may be available (and potentially, at reduced frequency). In those cases where regulators may write more prescriptive regulations that result in inspection and maintenance at strictly controlled frequencies, that flexibility may be lost, such that worker actions may be required at times when less optimal industrial or radiological safety conditions may exist. In recent years, more regulatory agencies are using the opportunity to write performance-based rules rather than prescriptive rules, meeting the regulatory mandate to protect public and workers while also supporting the principles of effective work management.

Establishing and maintaining a robust nuclear safety culture, and by reasonable extension, a robust (nuclear, industrial, radiological, and environmental) safety culture, usually is said to depend on a series of principles such as the following, as stated in an INPO document (2009):

1) Everyone is personally responsible for nuclear safety.
2) Leaders demonstrate commitment to safety.
3) Trust permeates the organisation.

4) Decision making reflects safety first.

5) Nuclear technology is recognised as special and unique.

6) A questioning attitude is cultivated.

7) Organisational learning is embraced.

8) Nuclear safety undergoes constant examination.

As noted above, this document is not designed to delve deeply into those principles; INPO and WANO documents and representatives should be consulted for details. Making a few comments may, however, help to illustrate application to balancing multiple contributors to overall risk.

Multi-disciplinary input is sought to help ensure that the work management process is used effectively and all risk contributors are considered. Integration of input from organisations such as operations, maintenance, system engineering, radiological protection, and in-service inspection, for example, is desired in planning work which considers relevant plant and industry historical information and also the applicable regulatory requirements. The principles stated above are used by each stakeholder in the process, with "craft"-specific information and perspectives brought forth by each stakeholder. That is, varying points of view are solicited to improve the end product of the work management process.

Mention should be made that the consequences of exposure to the several risk agents may be estimated in at least two different ways. For some risks (e.g. falling off a ladder), the consequence may be an injury (e.g. a leg fracture) to the worker which is immediately visible and for which corrective measures can be immediately taken (e.g. leg set and put into a plaster). For some other risks (e.g. exposure to a relatively low radiation field for several hours), the consequence may be able to be estimated only as a slightly elevated probability of contracting cancer or some other disease at some number of years in the future. The efficacy of any immediate corrective measure is likely to be low. Comparisons of risks of exposure are thereby made more difficult absent the participants being aware of the types of potential consequences and reasonable means of estimating the probabilities of the occurrence of such consequences.

There are two distinct but complementary systems used during communications within and among groups and in individual planning efforts. The first system includes the objective, history-based policies, procedures, and plans applicable to the work evolution being considered. Use of that documentation is important to ensure that lessons learned from previous job evolutions are appropriately considered. The second system includes the "more subjective approach based on intentions and culture – feelings, personal issues, trust, fairness and values." (Richard, 2011) Use of that second system is also important to ensure that safety leadership is clear and that the work environment is designed to allow people to work safely, as is their desire. Principles numbered above as 2, 4, and 6 are perhaps the most obviously used in this second system. A related principle, numbered 3 above and discussing trust permeating the organisation, may be illustrated by a series of questions that may be asked in promoting teamwork and the philosophy of the primacy of safety (Seybold, 2003).

Those questions are as follows:

a) Can I trust you?

b) Do you care about what you are doing?

c) Do you care about me?

Question b) may at virtually all times be found to be answered in the affirmative, but on infrequent occasions may lead to answers to be addressed by group supervision. As stated by Seybold (2003), trust results in people becoming part of the team, promoting

the offering of the individual insights and perspectives that lead to a job evolution which is performed with all relevant risk contributors being addressed.

Trust among team members and maintenance of an open mind regarding insights offered by other team members may be of most help when work evolutions involving multiple risk contributors are planned. Each work group will tend to have policies, procedures, and informal work practices reflecting their own perspectives and experiences, e.g. a good way for mechanics to repair an isolated ball valve. Continuing with that example, if the valve happens to contain a thermally heated radioactive solution, and/or if that line can be taken out of service for only a short time without elevating nuclear safety risk, and/or if complete isolation of the valve may be difficult, then multiple contributors to risk are present and are to be evaluated. Multidisciplinary input is essential to identifying all relevant risk contributors, assessing the potential for transfers of risk or interactions between risks, and developing a risk management plan acceptable to the various work groups involved in the work management process. Pertinent questions for consideration include the following:

- How well do we understand the risks we are balancing?
- Have all affected work groups provided their insights regarding anticipated risks, potential consequences of proposed actions, and optimal means to reduce those risks and avoid unintended consequences?
- Has a "radiological versus non-radiological" mentality been avoided, to ensure that complementary and balanced approaches to risk reduction have been developed?
- Do we have leading or lagging indicators of the ongoing adequacy of the work plan as the work progresses?
- Do we have clear "stop-work" criteria if assessments of barriers and defences suggest they may no longer be adequate for safe completion of the work?

The consideration of human factors is important in plant design and in the day-to-day work management process. As stated in OECD/NEA (2010), examples of items to be considered in the design process (but which also may need to be considered in the operational work management process) include the following:

- visual factors (e.g. adequacy of signs, readouts, and lighting);
- auditory factors (e.g. enabling important communications, minimising background noise, ensuring appropriate volumes of alarms);
- human physical characteristics (e.g. use of lifting devices and special tools, avoidance of heat stress, provisions of lifelines or other egress contingencies for confined area entries);
- human error prevention (e.g. use of colour-coded tools, alignment/location markings, interlocks and warning lights or alarms).

An important time for consideration of relevant contributors to risk is during the pre-job briefing before the work evolution is commenced. If the work management process to that point has not resulted in the work plan addressing all relevant risk contributors (or to confirm that the process did indeed consider those contributors), workers and supervisors to be involved in the evolution may use the pre-job briefing to discuss the management of risk contributors for the job evolution. Critical steps in the evolution may be described, error-likely situations may be confirmed or identified, the potential for flawed or inadequate defences may be discussed, and potential consequences of inappropriate action may be stated. A useful tool may be the use of a SAFER dialogue (Cameron, 2009), including:

Summarise critical steps
Anticipate hazards
Foresee consequences
Evaluate defences
Repeat back

Effective use of pre-job briefings may result in a modified task or work environment, modified defences, and added contingency measures to better address risk contributors for the job evolution.

French plants use a multi-disciplinary committee to assess and address risk for upcoming works. The objective of the committee is to consider risk prevention, industrial safety and health, radiation protection, the transport of potentially dangerous goods, and environmental safety (EDF, 2008). At other nuclear power plants, there is often a management committee to review the adequacy of planning to address risk for work which is deemed to be especially complex or is infrequently performed. At some nuclear power plants, there is also an environmental assessment process evaluating the likely consequences of plant modification that may be expected to increase either the thermal power output or effluents from the plant. Results from such an assessment would be used as an input to the work management process for a proposed modification.

Means to ensure consideration of all relevant contributors to risk for workers and the public are not readily described in words or in a decision-making flowchart. The consideration of relevant risk contributors is complex and results in decisions based at least partially on judgments by experienced and well-trained personnel. As described above, there are some means that plants and regulators may use to substantially improve the likelihood of their processes' resulting in effective consideration of contributors to risk. For example, are there visibly supported means for workers with differing backgrounds and perspectives to provide input to the work management process? Are both objectives (document-based) and informed subjective (knowledge- and values-based) inputs used in considering risks? Are human factors engineering and human error reduction techniques built into the work management process? Are there deliberate multi-disciplinary pre-job discussions of risk contributors and adequacy of barriers to prevent unintended consequences? Does management become involved in the review of proposed job evolutions which may pose risk which may be elevated compared to most work evolutions?

As stated above, when a work evolution is deemed necessary to maintain nuclear safety (or at least, to prevent imminent or likely threats to protection of the reactor core, pressure boundary, or containment), the work evolution is justified and there may be impacts on workers (and potentially even members of the public) resultant from performance of that work (note that such impacts may be positive – e.g. reduction of later potential risk – and/or result in some near-term dose or non-radiological risk to be managed). The caution for the operations staff and senior management is to ensure (using a nuclear-safety-first decision-making process) that the work indeed needs to be performed in the near term rather than at a later time when industrial, radiological, and/or environmental risk contributors may be able to be mitigated more effectively. For those work evolutions which are not deemed important to safety but are important to the reliable production of electricity, the work management process should be used to determine when impacts to production, workers, and the public may be minimised effectively.

Considering industrial safety, the intent should be to avoid evolutions that place the workers in a situation where there is imminent risk to the workers' health and safety. As with radiological safety, the objective should be to maintain non-radiological risks to the

worker at levels which are as low as reasonably achievable. If there is non-radiological risk (e.g. high temperature environment) to the worker, time spent in the condition should be minimised to the extent reasonably practicable, consistent with high quality job performance.

As to radiation risk, the intent should be to avoid evolutions that place the workers in a situation where anticipated dose rates and doses are very high. The objective should be to maintain radiation exposure to the worker at levels which are as low as reasonably achievable. Consistent with the typical attention to evaluating time in the radiation field during the optimisation process, time spent in radiation fields should be minimised to the extent reasonably achievable, consistent with high quality job performance.

Environmental risk may be tied directly to nuclear safety in many situations. That is, reduction of nuclear risk may result in reduced environmental risk. There is one other element to be considered, that of risk transfer from members of the public to workers or *vice versa*. For example, reduction of radiological effluent released from the facility to the environment in normal operations may in some cases be achieved by techniques that result in higher risk (e.g. doses) to workers as they manage the radioactive materials that would otherwise have been released to the environment. Risk should be allocated in a well balanced way to optimise total risk to affected stakeholders by taking into account the relevant decision criteria, including societal factors.

Making rational, balanced decisions when multiple contributors to risk are involved means considering the following types of questions for the risk contributors:

- Have reasonable actions been taken to eliminate each of the risks, without transference of risk from one contributor to another?
- Are the consequences of exposure reasonably measureable or reasonably able to be calculated? What are the levels of uncertainty in the estimates of consequence?
- How do the estimates of consequence compare in magnitude? This should include consequences to a single individual and groups of individuals. This should also include consideration of consequences expected to appear in the immediate future (e.g. hours/days) as compared to the intermediate term (e.g. weeks to a few years) or the longer term (e.g. a decade or longer).
- Can reasonable actions be taken to reduce overall risk to the relevant stakeholders, with an acceptable increase due to one (or a few) risk contributors? For example, can the work activity be deferred to a time when risks from several contributors can be reasonably reduced?

The depth of investigation into questions of such types, and the level of documentation of such investigation, should be proportional to the magnitudes of reasonably estimated consequences for the proposed work activity. A reasonable depth of investigation may involve only minutes of discussion by craft workers and their supervisors for some day-to-day activities similar to work evolutions that have been conducted in the recent past. On the other hand, deliberations regarding a proposed complex facility modification may require substantial discussion and documentation occurring over a period of months.

Key points

- Well-balanced solutions addressing the multiple contributors to overall risk are to be developed, optimising the overall risk to the affected stakeholders.
- Risk optimisation efforts should utilise both: *i)* objective, history-based policies and procedures; *ii)* views based on a strong safety culture and the value of professional individual and group insights to safe performance of a job.

- Human error reduction techniques should be used in plant design and operations. Effective communications among affected work groups and individuals is an important element in selecting, planning, and executing work to be performed.
- As a part of the management information system, the attention of high level managers to adequacy of the work management process should be elevated whenever any component of risk appears to be elevated. The same is true whenever the work evaluation process identifies transfers of risk or substantial interactions between risks may reasonably occur.

Examples of risk allocation and balancing

The following examples are intended to provide guidance to members of plant staff and regulators.

The first example was described by Mr. Deboodt (2000) as "ladder syndrome". A worker placed plastic bags around the rubber foot plates of a ladder to avoid potential radiological contamination of the foot plates. The ladder moved (slid) while the worker was on the ladder, resulting in serious personal injury to the worker. This example shows an inappropriate risk allocation. The worker increased the industrial safety risk (and indeed suffered personal injury) to reduce the potential for a likely minor contamination of the rubber foot plates of the ladder.

Also based on an example from the same presentation (Deboodt, 2000), the decommissioning of nuclear installations gives rise to jobs involving the potential exposure to physical-chemical agents such as acids and asbestos. The objective is to ensure that both the radiological and non-radiological risks to workers are adequately addressed. The use of an effective work management process (including the deliberate reviews inherent in the radiological optimisation or ALARA process) should result in effective risk mitigation related to the several risk agents. A related example which may occur in some operating plants would be stripping asbestos-containing insulation off of piping which may contain heated, radioactive fluids or be done in an area with an elevated radiation field (e.g. >1 mSv/hour).

Based on another example described at an International ISOE ALARA Symposium (Avetisyan, 2009), planning for electric and gas welding jobs requires the consideration of both protection of the eyes from the light emitted during welding and also prevention of aerosol inhalation, which may contain radiological and non-radiological constituents. Welding may for example be performed in areas equipped with local exhaust ventilation. Similarly, grinding is another activity which may require protection from both radiological and non-radiological agents. The use of an effective work management process should result in effective risk mitigation related to the several risk agents.

In another example cited by the same author (Avetisyan, 2009), hand protection via rubber gloves resistant to chemical agents specific to the Armenian site and job evolution is used in combination with cotton gloves. This exemplifies the consideration of both radiological and non-radiological risk agents in planning for work at the Armenian site. In a broader context, the use of protective clothing to reduce the potential for personal radiological contamination is used at all nuclear power plants and several other types of nuclear facilities. The potential for contamination being addressed may be from loose radioactive material, or it may be from discrete radioactive particles (DRPs, which are small, highly active radioactive particles) capable of contributing to relatively high dose rates in a localised area of the skin. In some areas of nuclear power plants (e.g. the reactor cavity), the potential for loose contamination and/or DRPs is significant enough that multiple layers of protective clothing may be specified for radiological protection. In areas where water may be found, that clothing may include plastic suits or other water-resistant materials. The balance with non-radiological risks may then include the consideration of the potential for heat stress among the workers. Generally, the more

protective clothing that is worn, the more potential there is for heat stress to occur. (Heat stress may also be proportional to the temperature in the work environment, the duration of the work activity and the amount of exertion by the worker to complete the work activity.) In some cases, heat stress may be mitigated by the use of cooled vests worn by the worker or the use of cooled "clean" air provided to the face of the worker. The balance between reduction of the potential for personal contamination and for heat stress is an important one in many nuclear power plants, and ensuring an appropriate balance requires communication between the work craft, radiological safety and non-radiological safety supervision in the planning and execution of the affected job evolutions.

The use of "portable" scaffolding, ladders, and/or lift devices is another situation where a balance needs to be achieved in communications between craft, radiological safety, and non-radiological safety personnel. The workers need to be assured that there is an appropriate and safe work platform from which to perform their assigned duties. Radiological safety personnel wish to ensure that the amount of time spent in a radiation field is reduced to the extent reasonably achievable (which may also be proportional to execution of the task in the shortest reasonable time frame). Operations personnel wish to ensure easy access to equipment important to plant safety and reliability, with that ease of access potentially compromised by placement of scaffolding or lift devices. The alternative approaches need to be discussed and the work option chosen to perform the task in a safe manner in the shortest reasonable time period in the radiation field.

Making a confined space entry may also be a situation where several risks need to be considered and a balance achieved to reduce risks to workers. The area to be entered may be oxygen-deficient or the atmosphere may contain chemical or other contaminants which may threaten human health. Regulations or procedures may specify the need for the presence of trained rescue personnel and their associated equipment. A complicating factor may be the presence of elevated workplace temperatures and/or radiation fields or fluids or sludge containing radioactive materials or biological compounds. Optimisation of the resources to apply to the job and the balancing of the various risks to the workers is necessary.

When a plant decides that chemical decontamination of a portion of the reactor systems is to be evaluated for performance, multiple risk agents need to be addressed. As the chemical agents are introduced into and drained from the relevant reactor system, nuclear safety is to be considered, to ensure maintenance of cooling of the reactor core and assurance of fuel integrity. Potential consequences of the use of the chemical agents need to be addressed, both in terms of an inadvertent loss of some volume of the agents and also in terms of the effects of any residue of the agents remaining in the reactor system. Volumes of the chemical agents may also be heated, adding another potential risk agent for workers near the fluid storage and transfer tanks and piping. Radiological consequences also need to be addressed, as a likely goal of the decontamination process is removal of a large amount of activity from the reactor system to containers to be shipped to a licensed waste storage or disposal site as radioactive waste. That implies that large amounts of activity are being moved through temporary piping and hoses, and that tanks with substantial activity contained inside are to be placed at (likely) temporary locations during the process. A result of a successful evolution may be reduced radiation fields within the nuclear power plant to which workers may be exposed. Environmental safety is also a factor, as there may be a reduction in airborne or waterborne effluents from the facility, or an increase in the effectiveness of production of electricity from the plant from a successful decontamination evolution, offset to some degree by the shipment of an increased amount of radioactive waste in the near term. The complexity of a chemical decontamination process implies that the work management process is likely to involve many disciplines over a lengthy planning period, to ensure a safe and successful outcome.

In a broader context, physical-chemical agents are introduced into reactor systems on a routine basis at many plants (examples may be hydrogen injection or noble metals

applications at a boiling water reactor or depleted zinc injection at several types of plants). One objective of such introduction of physical-chemical agents may be to reduce radiation fields to which workers are exposed during selected job evolutions; another objective may be to enhance the operational lifetime of a set of components important to nuclear safety. In planning for introduction of such agents, consideration must be given to nuclear, industrial, radiological, and environmental safety. As noted above, assessments may be complex to perform and may require informed management judgments as to the appropriate decisions. Specific to radiation safety itself, there may be inherent balances to be reached, as some proposals may increase radiation doses in the short term for some job evolutions while decreasing doses for other evolutions, or increase doses in the short term for some job evolutions while reducing the risk of having to perform a high collective dose evolution in the intermediate or longer term. Such decision making may also create more solid radioactive wastes for disposal to reduce doses to workers over the operating lifetime of the reactor.

Key points

- Systematic reviews of potential risks and means to address those risks are appropriate throughout the design and operational phases for the facility.
- Use of a "case-by-case" approach to risk evaluation and mitigation is appropriate, to reflect facility- and job-specific situations.

Final remarks

As it has conducted its work for CRPPH, the EGOE has consistently observed that the development and execution of effective occupational radiation protection programmes cannot be accomplished without considering the other programmes that simultaneously are developed and implemented at nuclear power plants and other facilities using radioactive materials. EGOE notes the efforts of the ISOE (also under the auspices of the CRPPH) in describing the multidisciplinary inputs for effective work management (OECD/NEA, 2009). In its first published case study, EGOE stated the principle that there is to be an "allocation of resources for occupational health and safety [which is] based on a rational balance between all risks in the context of total risk management." (OECD/NEA, 2010) In its second case study, EGOE stated that worker risk is to be assessed from the perspective of the multiple risk contributors in the workplace and the management of the environmental risk of facility operations. This should lead to "overall risk to the workers and from the facility (being) minimised to the extent reasonably achievable." (OECD/NEA, 2011). In the current study, EGOE expresses its further thoughts on the balancing of risks, whether by facility operators or by regulators as they carry out their oversight of those operations.

The simultaneous consideration of multiple contributors to risk to workers and the public is a complex undertaking. Development of flowcharts and/or procedures which address all of the relevant factors and quantify all of the elements of balanced decision making is perhaps even more complex and is potentially impractical for some facilities and situations. Absent those flowcharts and/or procedures, however, there are methods which, when used effectively, may lead to more optimised allocation of resources and balance in risk decisions. At the same time, there is the need for further study in defining interactions between different risks and in setting priorities on the different risks (related to potential consequences and their likelihood of occurrence).

In this document, the following programme attributes are described. Some and perhaps all of the attributes may be used (informally or formally) at well-managed facilities and by effective regulators. Their consistent use and enhancements in their means of implementation may be expected to lead to ongoing improvements in the performance of facilities and in their oversight.

- Well-balanced solutions addressing the multiple contributors to overall risk are to be developed, optimising the overall risk to the affected stakeholders.
- Effective processes for integrated risk management will always remain in development, because: *i)* society's perspectives on risk are dynamic; *ii)* scientific understanding of risks and their interactions improve with time; *iii)* techniques for work performance evolve with time and technology. Facility operators and regulators should remain aware of emerging changes regarding these factors and should encourage reasonable continuing efforts to enhance scientific understanding and work performance techniques.
- Evaluation of multiple risk contributors and development of plans for risk mitigation require management attention. This is especially true if transfers of risk or interactions between risks may be involved. Senior facility managers must ensure that they strongly and continually demand the consideration of the relevant risks and the bridging of any communication gaps in making balanced decisions involving multiple contributors to risk. Regulatory personnel should ensure both that facility managers are executing a reasonable process for considering the relevant risk factors in an integrated fashion in operations decision making and also that regulatory guidance encourages such an integrated assessment.
- The work management process may be used effectively in integrated risk management. Multi-disciplinary involvement in work selection, work planning, work scheduling, and work execution (e.g. pre-job briefings and communications during work performance) helps ensure identification and consideration of all relevant risk contributors.
- As a part of the management information system, the attention of high-level managers to adequacy of the work management process should be elevated whenever any component of risk appears to be elevated. The same is true whenever the work evaluation process identifies transfers of risk or substantial interactions between risks may reasonably occur.
- Systematic reviews of potential risks and means to address those risks are appropriate throughout the design and operational phases for the facility.
- Use of a "case-by-case" approach to risk evaluation and mitigation is appropriate, to reflect facility- and job-specific situations.
- Risk optimisation efforts should utilise both: *i)* objective, history-based policies and procedures; *ii)* views based on a strong safety culture and the value of professional individual and group insights to safe performance of a job.
- Human error reduction techniques should be used in plant design and operations. Effective communications among affected work groups and individuals is an important element in selecting, planning, and executing work to be performed.
- A training course should be developed wherever practicable, to provide the basics of integrated management of risks. Course content should make use of practical examples and address management's best judgment on the adequate and desired elements of workplace and facility safety. At the time of writing of this report, such a course (for facility design and operations personnel or for regulatory agency personnel) may need to rely more heavily than ultimately desired, on decision making using professional experience and professional judgment, informed by best practices at well-managed facilities and regulators. Contents of such a course may evolve with time, as more data emerges on means to better compare and contrast risks and their potential consequences using more quantifiable factors.

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ANNEX 1: CONSOLIDATED RESPONSES FOR SURVEY ON TRANS-BOUNDARY OUTSIDE WORKERS

A worker from another country intends to work temporarily in your country in a radiation controlled area (e.g. in a nuclear power plant during a periodical revision).

1) *What sort of dose (exposure) data does your regulatory authority require in order to allow the worker to access a controlled area? Please identify in terms of:*

Country	**a) Data about previous/current-year estimated doses to the worker as recorded by operational dosimetry (for example, electronic dosimetry or direct-reading dosimeters, sometimes documented in a radiation passbook carried by the worker).**	**b) Data about previous/current-year doses of the worker from official "dose-of-record" dosimetry (usually database extracts from accredited dosimetry services or central dose registers).**	**c) Other dose (exposure) data (please specify).**
Canada	Yes, data about previous/current-year estimated doses is required.	Recommended but not required. The information is required; however, it does not need to come from an accredited service. In Canada, dosimetry services are licensed by the CNSC and therefore other accreditations are not recognised under the regulations.	In Canada, the Radiation Protection Regulations require compliance with five year effective dose limit and a one year equivalent dose limit for any work authorised by a licence. To comply with these requirements, licensees hiring outside workers must obtain the dose data for the current five-year period. The dose limit applies to the calendar year (1 January to 31 December).
Finland	Regulatory authority (STUK) does not make any decisions concerning the start of the radiation work. The employer of the worker and the licensee (NPP) are in charge of assuring that the worker is fit for the radiation work. Exposure data as per a) or b) is required depending on data available. Mainly a).		
France	According to French regulations, an employer who temporarily transfers workers onto French territory or an independent worker coming onto French territory for working shall be subject to all the requirements of the labour code. Further, the undertaking shall make sure that the employer of the outside worker enforces the requirements it is responsible for, taking into account the specificity of the installation (a nuclear power plant for example, controlled area, etc.) before, during and at the end of the work. On this basis, the undertaking shall check with the employer of the outside worker that the outside worker has not exceeded, during a rolling twelve-month period, the effective dose limit (sum of the external passive dose and the internal dose) as well the equivalent dose limits fixed by the labour code. Concerning workers transferred by an employer from another country, there is no specific requirement in the French regulations on the way both the employer of the outside worker and the undertaking exchange the dose data of the workers.		
Country	**a) Data about previous/current-year estimated doses to the worker as**	**b) Data about previous/current-year doses of the worker from official**	**c) Other dose (exposure) data (please specify).**

	recorded by operational dosimetry (for example, electronic dosimetry or direct-reading dosimeters, sometimes documented in a radiation passbook carried by the worker).	**"dose-of-record" dosimetry (usually database extracts from accredited dosimetry services or central dose registers).**	
Sweden	It is requested to have dosimeter data covering the last five years and the current year in either dose passport (requested within the European Union) or via extracted data from an official dose register. In both cases it might be needed to supplement this data with preliminary dose information from the last time period (time period since last official dosimeter evaluation) which could be written into the dose passport or be supplied by extraction from an electronic work dosimeter system.		
Turkey	Documented in a radiation passbook carried by the worker.	Extracts from accredited dosimetry services or central dose registers.	
Romania		Data from official "dose-of-record" dosimetry is used.	
Belgium	Data about the "official" doses of the last 12 months of the worker, provided by the employer of the worker to the undertaking. These data are based on the records of the accredited dosimetry services transmitted to the employers. In the system under construction, all relevant dose data of the worker ("official" doses of previous and current years + any available doses from operational dosimetry) will be made accessible online to the undertaking by the employer once the contract between the employer and the undertaking is fixed.		
Spain	Answer c). A dosimetry passport is required in Spain for outside workers. In accordance with EU Directive 90/641/Euratom, this passport includes: worker life dose up to the time the passport is opened, effective dose received at the five previous years from external and internal exposures, doses received at each facility where the worker has been working, reported by the licensee of the facility from results of operational dosimetry (external) and body counter (internal) and dose received (reported by the worker employer from official dosimetry).		
Germany	*Preliminary note: Foreign companies who send their workers as outside radiation workers to Germany usually have a subsidiary company or a branch of the parent company in Germany. This makes it easier to cope with the German administrative requirements for outside workers.* The regulatory body requires official "dose-of-record" data [term b)] from previous years and the current year (effective dose and organ doses, if relevant, and accessed). In addition, data on the occupational exposure (effective dose) during professional time ("occupational life time dose"). In addition, the regulatory body requires exposure data from operational dosimetry of each nuclear installation (including NPPs) to which the outside worker had access. Both official and operational dose data allow determining the exposure of the outside work for the period before entering the current controlled area. In Germany, all official dosimeters are non-electronic and evaluated by official dosimetry services on a monthly base. As a consequence, official dose data for the current and previous month are usually not yet available. All this information shall be documented in the German radiation passport. In case of workers come from foreign countries, this information will be requested as well. Compliance of dose records from foreign countries with the requirements of the German radiation passport will be assessed by the regulatory body of the nuclear power plant.		

Country	a) Data about previous/current-year estimated doses to the worker as recorded by operational dosimetry (for example, electronic dosimetry or direct-reading dosimeters, sometimes documented in a radiation passbook carried by the worker).	b) Data about previous/current-year doses of the worker from official "dose-of-record" dosimetry (usually database extracts from accredited dosimetry services or central dose registers).	c) Other dose (exposure) data (please specify).
Poland	The dosimetric passport is issued by the President of the National Atomic Energy Agency based on a written application from the external employer or individual worker if he or she is working as self-employed. The dose record should include at least four years prior to issuing the passport, according to the Central Register of Doses. The dose record has to include: 1) External exposure: a) equivalent dose for skin (mSv); b) equivalent dose for hands, arms, feet and shanks (mSv); c) equivalent dose for lens of the eye (mSv); d) an effective dose. 2) Internal exposure: a) intaken radionuclide; b) nuclide activity in the organism (Bq) together with evaluation method: *i)* LCC whole body counter; *ii)* LO organ specific counter; *iii)* BU urine testing; *iv)* BX-excrement testing; *v)* dose in a tissue or organ and relevant calculation parameters, committed effective dose (mSv).		
United States	NRC licensees are required to obtain prior dose data if the individual is required by 10 CFR 1502 to be monitored. That is, that the individual is likely to exceed a certain fraction of any of the applicable dose limits, or they will enter a high radiation area. The type of information required to be obtained is specified on NRC Form 4 (cumulative) and Form 5 (current year). Cumulative or lifetime dose records are only required if the licensee intends to authorise the individual to receive a planed special exposure.		

2) From whom is this dose information for the outside worker requested (worker, licensee, other)?

Canada	Dose data comes essentially from the contracting company that employs the worker or the worker supplies the information prior to start (by completing and signing a dose data form provide by the NPP). Note: if the previous dose records are filed with the National Dose Registry "NDR" (at the worker's request), these records will be flagged as foreign dose records.
Finland	The licensee (NPP) is in charge of collecting the dose information of the outside worker from the employer of the worker in question.
France	This dose information comes from the employer of the outside worker or the independent worker. Concretely, concerning the nuclear power plants, the exchange of information/data goes through the qualified experts ("competent persons in radiation protection" in French) of the employer and of the undertaking: the existence of both these persons is mandatory in the regulations.
Sweden	The licensee and the employer of the outside worker should co-operate so that the needed dose information is secured before any work is started. The dose information is either a dose passport (inside European Union) which the employee should present or by extracted relevant data from an official dose register. This latter information the employee should present or have arranged to be transferred in a suitable way. Within Sweden, the information in the central nuclear industry dose register CDIS (medical check-ups, dose received at nuclear facilities and basic training courses) is available to the operators of the nuclear facilities. CDIS constitutes one part of the official National Dose Register which is a responsibility of Swedish Radiation Safety Authority.

Turkey	Worker should submit his/her registered (approved) dose information or radiation passbook.
Romania	From the outside undertaking.
Belgium	Mainly from the employer. In the system under construction: online accessible. The data are fed to the system by the health physics services linked to the undertakings.
Spain	As indicated in answer to 1).
Germany	The information is requested from the outside worker. In case of missing data, access to the radiation controlled area is strictly denied. The same holds if relevant data are expired (e.g. medical fitness) or if relevant German dose limits are exceeded.
Poland	For the period prior to issuing the passport: Radiation Protection Inspector of external employer or organisational unit. For each period when the passport holder performed work in the controlled area: Organisational unit Head or Radiation Protection Inspector.
United States	In general a completed Form 4 or 5, or equivalent, signed by the individual and countersigned by an appropriate official of the most recent employer or current employer (for temporary contract workers). However, licensees are also allowed to accept a signed statement from the individual, or from the individual's most recent employer or current employer (for temporary contract workers) for current year exposures. Records from the most recent employer or current employer (for temporary contract workers) can be obtained by telephone, telegram, electronic media, or letter.

3) *In your country, what period of time do dose limits that are applied to an outside worker refer to?*

Canada	Calendar year.	**Belgium**	Rolling twelve-month period.
Finland	Calendar year.	**Spain**	Calendar year.
France	Rolling twelve-month period.	**Germany**	Calendar year.
Sweden	Calendar year.	**Poland**	Calendar year.
Turkey	Rolling twelve-month period.	**United States**	Calendar year.
Romania	Calendar year.		

4) *Is verification of the information carried by an arriving worker required to be sought or received prior to the worker's accessing a controlled area? If yes, please specify the type of verification required.*

Canada	Not explicitly stated by the regulations; however, in order to comply with the regulatory dose limits, licensees need to obtain worker dose history before the worker accesses a controlled area. Generally, dose data submitted by the worker has to be signed by the worker, previous employer or by a dosimetry service. Regulations require worker to provide employer with their dose history (i.e. dose record for the current one-year and five-year dosimetry periods).
Finland	Previously incurred radiation doses to workers during the present year and five-year period shall be known before new radiation

	work is started at the nuclear facility. The licensee is in charge of the verification.
France	The respect of the dose limits shall be known prior to the worker's accessing a controlled area.
Sweden	Yes, the licensee must receive and check the dose information, dose passports, status of medical check-ups and the records of necessary education/training supplied. The legislation does not give room for any deviation on these issues for external workers. The check is in practice carried out by the staff at the reception of the nuclear facility but some controls and exchange of data can also be arranged in advance in order to simplify procedures. The important issue is that the control is made prior to commencement of work at controlled areas.
Turkey	Individual radiological monitoring document (passbook) including data provided by last employer abroad.
Romania	The declaration of the outside undertaking is required prior to the entrance of the outside worker in the controlled area.
Belgium	Yes, the doses for the last 12 months are verified to check whether the dose limit has not yet been exceeded and whether the mission will not lead to an excess of the dose limit.
Spain	Yes, Radiation Protection Service at the facility must check radiological passport of every worker at the time they arrive to the facility to verify that doses received previously and planned work are compatible with dose limits.
Germany	Before entering the radiation controlled area at the beginning of the stay at the site the outside worker has to pass a check-in procedure. During this procedure RP-relevant information as documented in the radiation passbook is transferred into the occupational dosimetric system of the NPP. Data to be transferred are: • official/operational exposure data (effective, organ) and occupational life time dose (for details please refer to the answer to No. 1); • expiration date and status of the mandatory medical survey (to be performed latest once every 12 months); • expiration date and status on the approval to work with respiratory systems (required, if the worker shall work with respiratory systems); • personal data on the worker (e.g. address, date of birth, gender); • radiation category; • information on the employer including date of start of radiation work (and end of radiation work, in case of change of the employer during period of validity of the radiation passport); • information on the radiation passport (e.g. number, expiration date, regulatory authority). The dosimetric service of the NPP is in charge of transfer of these data to the system and to check the data with respect to current dose limits, internal dose thresholds set to initiate additional internal approval processes in case of dose values closer to dose limits, and with respect to the expiration of relevant dates. In addition, the dosimetric service of the NPP checks consistency of the data and of the radiation protection passport. In case of any doubt on the correctness of any data the access to the controlled area is strictly denied. Typical follow-up activities in these cases are the clarification of data with the contractor company of the outside worker.
Poland	See answer to No. 1.
United	NRC licensees are required to request a written verification of the dose data if the authenticity of the data obtained by the means in No. 2 above, cannot be established.

States	

5) *Your country and the applicant's home country may have differently specified dose limits (e.g. 20 mSv/year vs. 50 mSv/year, calendar year vs. rolling 12-month period, etc.). What annual dose limits apply to the applicant?*

Canada	The Canadian dose limits specified in the RP Regulations apply for any worker authorised under the Canadian Nuclear Safety and Control Act.
Finland	*The effective dose caused to a worker by radiation work shall not exceed an average of 20 mSv per year reckoned over a period of five years, nor 50 mSv in any one year.* In order to keep individual radiation exposures low, additional dose constraints lower than the above mentioned shall be used at the nuclear facility. Annual doses over 20 mSv can be accepted only in justified exceptions, as in every EU member country.
France	Annual dose limits fixed by the French regulations are the only ones applicable to all the workers working on the French territory (20 mSv over a rolling 12-month period for the effective dose).
Sweden	In Sweden, the Swedish legislation is applied (max. 50 mSv per calendar year and 20 mSv average over five consecutive calendar years). For example, SSM has not allowed some workers from other countries to go above 100 mSv in a consecutive five-year calendar period. If an applicant's home country/organisation has lower dose limits/applies a lower dose constraint this issue has to be considered by the Swedish licensee/operator in planning the work and drawing up the commercial contracts. In summary, the application of a higher dose limit is legally not allowed, but limitations which effectively lead to stricter values are allowed.
Turkey	Article 9 of Directive 96/29 applies.
Romania	The Romanian limit of 20 mSv/year.
Belgium	The strictest one. Indeed, in Belgium the dose limit is 20 mSv/rolling 12-month period. The undertaking is bound to this limit and cannot allow anyone in its controlled area to exceed this limit. If an employee from a country where an even stricter dose limit is applied comes to Belgium, the employer of the employee is bound to this stricter dose limit.
Spain	Spanish dose limits apply to all workers while working in our country. When highly specialised workers from a country with higher dose limits need to perform any task at the end of which they may have received a dose above the Spanish limits special arrangements need to be put in place.
Germany	Consequently, only the German dose limits and obligations of the German Radiological Protection Ordinance are applied. The German annual dose limit shall be respected independently from where a dose was received. For example, the annual dose limit for the effective dose is 20 mSv/a in Germany; in case a worker from a country with an annual dose limit of 50 mSv/a wants to enter a radiation-controlled area, with an effective dose of 27 mSv accumulated in the present calendar year, the worker is rejected from access to the radiation-controlled area.
Poland	Dose limit 20 mSv per calendar year, with reservation of exceeding 50 mSv per year and not exceeding 100 mSv over five consecutive years. Additionally: 150 mSv for lens of eye, 500 mSv for skin, 500 mSv for hands, arms, feet, and shanks. Other restrictions apply for women and students.
United States	The US dose limits [i.e. 5 rem/y (50 mSv/y) TEDE, 50 rem/y (0.5 Sv/y) total organ dose, 15 rem/y (150 mSv/y) to the lens of the eye, etc.] apply to any individual working at a NRC licensed facility. The licensee would have to consider prior occupational dose received at their and other licensed facilities and occupational dose received from non-licensed facilities, such as a domestic government facility (i.e. DOE), or a facility outside the US, not licensed by the NRC.

6) *What other information does the regulatory authority of your country require from an outside worker from another country in order for the worker to be allowed to access a controlled area (e.g. medical record which indicates the physical condition of the worker as medically fit/conditionally/not fit, radiation protection training, and/or respiratory protection training)?*

Canada	The RP programmes implemented at licensed facilities do not differentiate between permanent or outside workers, therefore any work requirements will apply uniformly to all workers. The information required under the RP programmes includes medical records, radiation protection training and respiratory protection training.
Finland	The licensee shall ensure that the medical surveillance of an external worker has been organised according to the Radiation Act and Decree. The licensee shall keep a record of the performed medical examinations of Category A workers. Radiation protection training can be considered to be qualified for both Finnish nuclear power plants, if the plant-specific characteristics and differences have been taken into account in connection with training. For example, it is sufficient that written material is handed out to workers. On the same basis, radiation protection training in Sweden can also be approved at Finnish nuclear power plants.
France	The undertaking shall ensure that the employer of the outside worker enforces the requirements for which they are responsible, taking into account the specificity of the installation (a nuclear power plant, controlled area, etc.) before, during and at the end of work. It includes information on the worker's dosimetric status, medical fitness, and radiation protection training. In addition, a worker can be assigned to work exposing him or her to ionising radiation only after having undergone a medical examination by the occupational health physician and on condition that the fitness data sheet drawn up certifies that the worker has no medical contraindication for such work.
Sweden	Medical records are needed but also education/training could be accepted if performed and documented in a reliable way (e.g. co-operation with Finland). This information, however, can never replace the needed local information (information about the premises, alarms, local safety rules and other needed local RP and safety information).
Turkey	The licensee is responsible for their medical surveillance, training and other operational radiation protection issues.
Romania	Medical record which indicates the physical condition of the worker as medically fit/conditionally/not fit. If this is missing, the medical examination is made at the operator.
Belgium	Medical record which indicates the physical condition of the worker as medically fit/conditionally/not fit. In the future system also radiation protection training.
Spain	In addition to doses the mentioned radiological passport includes, for every worker, information related to: • employment changes undergone by the worker; • facilities where the worker has been working; • medical surveillance; • radiation protection training.
Germany	See answer to No. 4.
Poland	Medical decision on the admission to work in conditions of professional exposure to external radiation/internal contamination by authorised physician. Medical recommendations on contraindications related to the use of the measures protecting the respiratory system against radioactive contamination by authorised physician.

	Result of X-ray examination performed by physician (name, stamp, and signature). Sum of effective doses in four calendar years prior to the year of issuing the dosimetric passport (by Radiation Protection Inspector of external employer).
United States	NRC licensees are only required to provide a medical physical as part of qualifying a worker to wear a respiratory protection device. Training on the radiological hazards that a worker can encounter while working at the facility is required for all workers. However this general employee training is usually conducted by the licensee when the worker is first hired. Also, respiratory protection training is required; if the worker is to wear a respirator, the training is specific to the respirator used. Each licensee conducts the appropriate training as part of the qualification process.

A radiation worker from your country worked and received occupational dose in another country and returns back to your country.

7) Does your country register the occupational exposure doses of the worker received in another country?

Country	**a) If yes, how do you collect estimated dose and official dose-of-record information?**	**b) How do you provide data to other countries on occupational exposure accrued in your country?**	**c) Do you have any restrictions on privacy regarding dose and medical records?**
Canada	Yes, dose records filed with the National Dose Registry "NDR" (at the worker's request), are flagged as foreign dose records.	Question needs more clarification: It is not clear whether the question pertains to the mechanisms to transfer data or whether to specific organisations, etc. The NDR will provide the worker with an official dose record upon request. Generally, if the worker holds a dosimetry passport, the NPP will fill in the passport.	In Canada, the transfer of any personal information (including dose and medical records) is subject to the Privacy Act.
Finland	If an employee of a Finnish employer performs radiation work abroad while in the service of the said Finnish employer, then pursuant to Section 35 of the Radiation Act, the employer must ensure that data on the worker's radiation exposure are reported to STUK for recording in the Dose Register. When an employee of a Finnish employer returns to Finland after performing radiation work abroad in the service of a foreign employer, then before any work begins in Finland the Finnish employer must ensure that data on the worker's radiation exposure abroad are properly reported to the STUK Dose Register. The radiological monitoring document included in a radiation passbook is used to report the radiation doses sustained by the worker abroad to the Dose Register.	Occupational exposure data to the other countries is provided in outside workers' dose pass books (or equivalent) by the licensee. The radiation safety authorities and nuclear power plants of Finland and Sweden have agreed on a procedure whereby nuclear power plants in each country report the doses sustained by a worker directly to the dose register of the worker's country of origin. This means that a Finnish person going to work in a Swedish nuclear power plant does not need a radiological monitoring document in order to report doses sustained in Sweden to the STUK Dose Register. However, workers must notify the Swedish nuclear power plant of their prior radiation exposure. This may be done using an extract from the Dose Register requested from STUK, which will contain details of the worker's entire dose history. The worker may also notify this information using the latest annual summary received by a Finnish employer from STUK together with a dosage	Under Section 26 of the Personal Data Act, a worker whose data are recorded in the Dose Register is entitled to inspect the said data. The worker may request an extract from the Dose Register for this purpose. Details of a worker's radiation exposure may be released without the worker's consent from the Dose Register to the medical practitioner responsible for medical surveillance, referred to in Section 33 of the Radiation Act, and to the responsible party. These details may also be released to a responsible party in a member state of the European Union when this is necessary to meet the duties of an employer to monitor radiation exposure (Section 34 of the Radiation Act). A written request is required for release of information. The information will be released in printed form. The procedures for transmitting and processing this information must provide reliable guarantees of satisfying the data protection standards of the Personal Data Act.

		notification for the current year issued by an approved dosimetry service. If a nuclear power plant worker has been working for only one nuclear power plant, then a current dose notification issued by the dosimetry service of the nuclear power plant in question may be used for reporting details to the Swedish nuclear power plant.	

Country	a) If yes, how do you collect estimated dose and official dose-of-record information?	b) How do you provide data to other countries on occupational exposure accrued in your country?	c) Do you have any restrictions on privacy regarding dose and medical records?
France	If the worker is employed by an employer registered in France, the employer has the obligation to provide the worker with dosimeters (passive dosimeter plus operational dosimeter if working in controlled areas) and to register, in the French national dose register (SISERI), the doses received by the worker in France or in any other country. If the worker is registered in France as an independent worker, the requirements are the same as those of the employer. If the worker is employed by an employer registered outside France, the occupational exposure doses of the worker received in another country may be or not registered in the French national dose register, this is up to the stakeholders.	It is the responsibility of the employers registered in France to provide data on occupational data to stakeholders of another country (undertaking, authorities, workers, etc.) when they send their workers outside France. There are no regulatory requirements on the way to provide the data.	Only the occupational physician has access to the medical records and to all the doses received by the workers he/she is in charge of (external doses, internal doses, total effective doses, operational doses, and equivalent doses, whatever the period). The qualified expert ("competent person in radiation protection" in French) has access to the last 12 months of effective doses received by the workers of which he/she is in charge, as well as their operational dosimetry results.
Sweden	When a Swedish worker is performing activities abroad they should in advance have a dose passport. The dose passport is issued by the Swedish Radiation Safety Authority. The dose passport should be filled in with final (or at least preliminary) dose information. After returning to Sweden, the information in the dose passport should be entered in the Swedish dose register, either by the SSM (non-nuclear activities) or by the appropriate nuclear facility (nuclear facilities). Information on how this should be carried out is given to the person requesting a dose passport.		
Turkey	It is the outside worker's obligation to submit his/her dose record supplied by the employer abroad. The local employer	The worker submits his/her registered dose or the employer or relevant authority abroad may demand such data in the	Dose and medical records are only accessible if the worker indicates his/her consent.

	or relevant authority may also ask for such data through the employer or relevant authority abroad.	same manner answered for a).	
Romania	Only the recorded dose is collected from the dosimetric passport of the worker filled by the operator of the foreign country or from a bulletin sent later by the operator to the outside undertaking.	See response to a).	No.
Belgium	YES: radiation passbook (not yet implemented).	Fill in radiation passbook if they have one.	YES: privacy rules apply but if certain measures are taken to ensure the protection of the data, this does not compromise the use of these data.
Spain	The Spanish national dose register include doses from all workers wearing dosimeter badges read by dosimetry services authorised in Spain. If the worker has been abroad with a dosimeter badge provided by a Spanish dosimetry service, registry of the reading will be assured. In case of use of dosimeter badges provided by a foreign dosimetry service, a dose certification must be sent by the Spanish employer to the regulatory body for the readings to be included in the national registry.		

Country	**a) If yes, how do you collect estimated dose and official dose-of-record information?**	**b) How do you provide data to other countries on occupational exposure accrued in your country?**	**c) Do you have any restrictions on privacy regarding dose and medical records?**
Germany	In general, the exposure of a German worker in foreign countries should be subject to official dosimetry and measured with German dosimeters as the employer is a German company/institution and as such subject to the German Radiological Protection Ordinance. Alternative ways of measuring the dose might be possible in rare and justifiable cases and only with written agreement from the regulatory body responsible for the employer (e.g. by using official dosimeters of the foreign NPP). In such a case the dose data will be transferred to the national dose register (via the official dosimetric services); the doses shall also be recorded in the German radiation passport of the worker.	By means of the radiation passport, if needed by translation of relevant numbers.	Yes, these data are subject *inter alia* to the German Data Protection Act. Nevertheless, a suitable abstraction of the relevant data is covered by the German radiation passport (see e.g. answer to No. 4) and thus these restrictions do not jeopardise the objectives of an effective radiation protection.
Poland	The responsibility of the dose record in	There is Central Dose Registry under	Both are regulated by the Law on

	the central dose registry belongs to the employer.	control of the NAEA.	Protection of Personal Data. The dosimetric passport is subject to the same rules as a normal passport.
United States	The US does not have a national dose registry. Licensees record the workers cumulative dose history on Form 4, including doses received by non-NRC-licensed sources.	NRC licensees are required to provide a copy of dose records at the individual's request.	Yes the US does have privacy regulations on the handling of personally identifying information, including dosimetry records. This is in part why we require records to be provided at the individual's request.

General response to the survey

Denmark	Being a member state of the European Union, Denmark has implemented Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionising radiation during their activities in controlled areas. The requirements in the Danish legislation are therefore identical to the provisions in the Directive. I attached the directive and the relevant Danish Order (in Danish). Denmark in all cases applies a strict dose limit of 20 mSv/y (calendar year) for occupational exposed workers.

ANNEX 2: CRPPH EXPERT GROUP ON OCCUPATIONAL EXPOSURE (EGOE)

BELGIUM

Pascal DEBOODT	Belgian Nuclear Research Centre (SCK•CEN)

CANADA

Salah DJEFFAL	Canadian Nuclear Safety Commission (CNSC)

FRANCE

Caroline SCHIEBER	Nuclear Protection Evaluation Centre (CEPN)
	ISOE European Technical Centre
Marie-Line PERRIN	Nuclear Safety Authority (ASN)
Olivier COUASNON	Nuclear Safety Authority (ASN)

GERMANY

Gerhard FRASCH (*Chair*)	Federal Office for Radiation Protection (BfS)

POLAND

Pawel KRAJEWSKI	Central Laboratory for Radiological Protection (CLOR)

SLOVENIA

Borut BREZNIK	Krsko Nuclear Power Plant
	ISOE IAEA Technical Centre

UNITED STATES OF AMERICA

Richard DOTY	PPL Susquehanna, LLC: Susquehanna Steam Electric Station
	ISOE North American Technical Centre
Willie O. HARRIS	Exelon Nuclear
	ISOE North American Technical Centre
David W. MILLER	Cook Nuclear Plant
	ISOE North American Technical Centre
Sami SHERBINI	US Nuclear Regulatory Commission

INTERNATIONAL ORGANISATIONS

Jizeng MA	International Atomic Energy Agency (IAEA)

	ISOE IAEA Technical Centre
Stefan MUNDIGL	European Commission (EC)