Unclassified **NEA/CRPPH/R(2011)1**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **13-Sep-2011**

English - Or. English

Nuclear Energy Agency

NEA/CRPPH/R(2011)1
Unclassified

Committee on Radiation Protection and Public Health

Expert Group on Occupational Exposure

Dose constraints - Dose constraints in optimisation of Occupational Radiation Protection and implementation of the Dose constraint concept into Radiation Protection regulations and its use in operators' practices

This CRPPH report is also available on the NEA web page (www.oecd-nea.org) and as a printed publication.

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JT03306837

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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: Policy and practical issues in occupational radiation protection in nuclear power plants.

Case study 1 was completed and published as the NEA publication (NEA No. 6975) in 2010. Following the step-by-step approach advised to the Group by the CRPPH, the Group continued its work and prepared and finalised the draft of Case study No. 2, which was submitted to, and approved by the CRPPH at its 69th meeting in 2011.

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 2 was completed through intensive work of all Group members nominated by the CRPPH, and was accomplished during EGOE meetings through 2009-2011. This work was assisted by significant co-operation with three international organisations – ICRP, EU and WNA. 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

ADL	Administrative Dose Limit
ALARA	As Low as Reasonable Achievable
ALARP	As Low as Reasonably Practicable
BE	British Energy
BSS	Basic Safety Standards
BWR	Boiling Water Reactor
CDRL	Company Dose Restriction Level
CNSC	Canadian Nuclear Safety Commission
CRPPH	Committee on Radiation Protection and Public Health
CSN	El Consejo de Seguridad Nuclear (Nuclear Safety Council, Spain)
CY	Calendar Year
EC	European Commission
ECL	Exposure Control Level
EDF	Electricite de France
EGOE	Expert Group on Occupational Exposure
EPD	Electronic Portable Dosimeter
ERPAN	European Radiation Protection Authorities Network
EU	European Union
GAEC	Greek Atomic Energy Commission, Greece
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ISOE	Information System on Occupational Exposure
KKL	Leibstadt Nuclear Power Plant, Switzerland
NEW	Nuclear Energy Worker
NPP	Nuclear Power Plant
NSSS	Nuclear Steam Supply Systems
OPG	Ontario Power Generation
RCA	Radiation Controlled Area
RPII	Radiological Protection Institute of Ireland
RWA	Radiation Work Admission
RWP	Radiation Work Permit
SUJB	Státní uřad pro jadernou bezpečnost České republiky (State Office for Nuclear Safety, Czech Republic)
USDOE	U.S. Department of Energy
USNRC	U.S. Nuclear Regulatory Commission

EXECUTIVE SUMMARY

Introduction

It is generally accepted that for all justified planned activities, a prime radiological protection consideration is to reduce exposures as to become as low as reasonably achievable, economic and social considerations being taken into account. In order to assist in the planning of optimised radiation protection, the ICRP starting from 1991 recommends using dose constraints. Dose constraint was introduced as a value below which it should be planned to keep all doses. It is associated with a particular "source" and should not be interpreted as a dose limit. Selecting a numerical value of dose constraint for a particular source is not a simple task – it requires knowledge and experience. In addition, thorough consideration of the source conditions of a particular planned exposure situation is always necessary.

Object of the publication

The main aims of this publication are to analyse countries' and utilities' experiences with interpretation and implementation of dose constraints in occupational radiation protection, in regulatory and operational frameworks as they were introduced in the ICRP Publ. 60; to discuss operational and regulatory issues associated with their implementation; and to provide suggestions regarding operational objectives and uses of dose constraints in light of recommendations of the ICRP Publ. 103.

This publication addresses the implementation and use of the instrument and principle of dose constraint into a radiation protection regulatory framework. It describes the role of dose constraints in the process of optimisation of radiation protection, and provides explanations where necessary in order to avoid the possible situations where dose constraints are misinterpreted or used as a stringent limit. It provides and analyses existing national regulations and practices used by various operators, as well as identifying potential issues that need to be considered in the implementation and setting of dose constraints for the purposes of occupational radiation protection.

As such, it is directed primarily to operators in the nuclear industry, registrants and licensees in facilities and activities, relevant authorities in other sectors outside the nuclear industry and to regulators issuing and enforcing radiation protection regulations and guides.

It also analyses the development of the concept of dose constraint as a tool for optimisation of radiation protection, and provides references to relevant ICRP publications and Basic Safety Standards.

Since the publication primarily focuses on related aspects in occupational radiation protection, it does not directly address the use and application of the dose constraint concept for the protection of members of the general public or the environment. The conceptual aspects presented here, however, should be relevant when considering dose constraints in the context of public radiation protection.

Motivation and background

The analysis of approaches to implementing appropriately formulated radiation protection principles into radiation protection frameworks is one of the main aims of the CRPPH Expert Group on Occupational Exposure (EGOE). Following such a mandate, the EGOE performed the current study in order to provide a description of current application of the dose constraint concept in the optimisation of occupational radiation protection, in order to clarify the understanding of this concept.

The content of the publication

This publication is structured into Chapters, providing information on background, links to relevant ICRP recommendations and information on how these recommendations are introduced into international safety standards, primarily the International Basic Safety Standards – BSS-1996 edition (issued by the IAEA), and the Euratom Basic Safety Standards Directive – EU-Directive (issued by the Council of the European Union). It also provides examples on use of dose constraints and constraint-like concepts in both – the non-nuclear energy and nuclear energy sectors, and existing operators' experience where available. Discussion and information on novel principles and approaches as are in ICRP Publ. 103 are also discussed wherever appropriate. The following Chapters are included in the publication:

Dose Constraint in Light of the ICRP Concept

The Chapter provides information on the current use of dose constraints in optimisation of radiation protection based on recommendations in ICRP Publ. 60 and ICRP Publ. 101. ICRP Publ. 60 introduces the new concept of constraint to dose or to risk, which is meant to be an individual-related criterion applied to a single source in order to ensure that dose or risk limits are not exceeded. ICRP Publ. 101 further elaborates on the principle of optimisation of radiation protection below a dose constraint, aiming to keep the magnitude of individual doses as low as reasonably achievable, with economic and social factors being taken into account. The key factor is that optimisation should be performed (or should continue) below dose constraints, and as such, final optimised doses should also be at levels below respective dose constraints. The Chapter also provides information on strengthening of the role of dose constraint in the optimisation of radiation protection as it is introduced in the ICRP Publ. 103.

Dose Constraints in International and National Regulations

This Chapter provides information on the process of optimisation of radiation protection using dose constraints by providing answers to a set of questions covering various aspects relevant to the use of constraints in the non-nuclear energy sector. It is divided into two parts – the first introduces results of a survey performed by the European Radiation Protection Authorities Network (ERPAN) within member states of the European countries; the second provides similar information for Canada and the U.S.A.

Since all member states of the European Union are required to enact the EU-Directive into national legislation, the majority of them have already adopted the concept of dose constraints (or similar instruments). Some countries are also using identical terminology, i.e. dose constraints, while others use, for example, source related dose values, dose levels or similar terminology. Additionally, implementation approaches are not yet fully harmonised within the European Union. For example, there is no consensus as to whether there is a retrospective use for a prospectively developed constraint as a regulatory or management tool.

As for the countries of Northern America, in Canada the action level is used. However, the concept of an action level may not be identical with, nor the exact equivalent of, a dose constraint, since it is a level below a dose limit, which, if reached, may trigger certain actions to secure compliance with the dose limit. Contrary to a dose constraint concept, this approach does not explicitly require optimisation below the action level, and the action level may be enforced by the regulator (enforceability of dose constraint for purposes of occupational radiation protection is not intended in the concept introduced in the ICRP recommendations).

In the U.S.A., the use of dose constraint in optimisation is applied; however in general it is not directly linked to the optimisation process. And, if the dose constraint is exceeded, specified actions are required. Although some of the existing US NRC requirements function in a manner similar in concept to

the ICRP Publ. 103 definition of dose constraints, these were not developed as constraints, and in most cases are considered as limits, i.e. they may be enforced by the regulator.

In Japan, according to the Radiation Council, the advisory panel to the Government in charge of maintaining consistency within technical standards in the radiation protection regulations, it is considered that the current status i.e. the observance of the dose limit has been sufficiently achieved by the implementation of the strategy of the dose management for the workers based on the existing regulations. This suggests that uniform introduction of dose constraints in occupational exposure into the current regulatory system impedes the flexible and optimum management conducted by individual facilities. Therefore, it is considered as not necessary to introduce the dose constraints into national regulatory system in which the dose limit has already been introduced.

Dose Constraint and Revision of the Basic Safety Standards

The Chapter provides information on the revision of two safety standards documents (BSS-1996 edition and Euratom BSS Directive). These revisions aim to follow the revised ICRP recommendations (ICRP Publ. 103) to the extent possible. Revision of both documents aims also to establish dose constraints for occupational (as well as public – not addressed in this publication) exposures, and their use in optimisation of protection for a source.

Dose Constraint in Nuclear Power Plants – Operators' Practices and Experiences

The Chapter provides information on existing operators' practices and experiences in several NPPs. While it is evident that dose constraints or dose-constraint-like-instruments are used for radiation protection purposes in operation of NPPs, they are not necessarily explicitly related or linked to optimisation. While optimisation is required in most cases, its relation to dose constraints, where they exist, is not uniform; and the optimisation is not necessarily linked to their use.

Implementation of the ICRP Recommendations on Dose Constraints into Regulations – Issues to be Considered

The Chapter extensively describes, and provides several practical examples, on issues needed to be considered and/or clarified in implementation of the dose constraint concept into radiation protection regulations. The following aspects are introduced and elaborated in the Chapter:

(1) Constraint *versus* limit – only a linguistic problem?
(2) Dose constraints in prospective evaluations and as one means of initiating investigations of actual operations
(3) Risk of dose constraint being interpreted as an "additional" limit or as a new "standard of care" for workers
(4) Dose constraint as only one of many factors in total risk management
(5) Dose constraint in the process of optimisation
(6) Need for education and training specifically addressing dose constraint?

Analysis and Conclusions

Analysis and Conclusions provide brief summaries of the available information on the dose constraint concept in occupational radiation protection approaches, and its implementation into radiation protection framework.

It can be concluded that the actual implementation of dose constraints, particularly by operators in the nuclear industry, depends, in most cases, on individual approach and on co-operation between registrant

and licensee and the regulator. According to most existing practices, even if dose constraints (or similar instruments) are in many cases used, there are no dose constraint values required to be set *a priori* by national regulations.

As far as the optimisation of radiation protection is concerned, the legislation in most countries is currently based on ICRP Publ. 60. As such, in some cases protection of employees may be based on optimisation using dose constraints – i.e. intended to help ensure equity of dose distribution, while in other cases optimisation without dose constraints will be used, which may, in some cases, increase the probability of an inequitable distribution of doses among employees.

Most operators use a concept somewhat similar to that of dose constraint, as a benchmark value that enables (retrospective) evaluation and adoption of revised radiation protection measures when doses from their operations exceed the planned expectations, i.e. when occupationally exposed workers actually receive doses that exceed a planning value established for a set of tasks that were to be accomplished. This may be done separately from using dose constraint in a prospective fashion to plan optimisation of protection for the source. If the latter prospective application is not done for a new source or major tasks for an existent source, then the practice may not be fully in consistence with the concept as it is introduced in ICRP recommendations.

Appendices and References

Appendices providing the detailed results of ERPAN and ISOE surveys, list of used references, and list of EGOE members are provided at the end of the document.

I. INTRODUCTION

The concept of dose constraints is one that was extensively discussed during the development of ICRP Publication 103, and which continues to elicit concerns. In spite of these long discussions, no common understanding of the concept seems to have emerged. For example, some nuclear operators are concerned that introducing the term and principle of dose constraints into the regulatory system that already requires optimisation may pose an additional and unnecessary burden in already stringent regulations. To avoid potential misinterpretation there is a need to provide an explanation, as well as guidance, on the practical use and implementation of dose constraints in radiological protection.

The concept of dose constraints was first introduced by the ICRP in the Publication 60, in part 5.3.1 the optimisation of protection in occupational exposure, as: "*An important feature of optimisation is the choice of dose constraints, the source-related values of individual dose used to limit the range of options considered in the procedure of optimisation*" (ICRP, 1991). The new emphasis in more recent years on dose constraints has been one of the topics that has generated the most questioning and confusion during the development of the new recommendations. Dose constraints, in fact, have continued to provoke discussion as the ICRP recommendations are being translated into a regulatory language through the International Basic Safety Standards (BSS) and the European BSS Directive. Current practice shows large variability in interpretation and use of dose constraints in the management of doses among operators and licensees. But in some countries, dose constraints have also become regulatory tools and are implemented in the regulatory framework.

The ICRP in Publication 103, in Paragraph 198 (ICRP, 2007), re-enforces the principle of optimisation of radiation protection using dose constraints or reference levels, and emphasises that it should be applicable in a similar way to all exposure situations – planned, emergency and existing: "*The concepts of a dose constraint and reference level are used in the process of optimisation of protection to assist in ensuring that all exposures are kept as low as reasonably achievable, societal and economic factors being taken into account. Constraints and reference levels can thus be described as key parts in the optimisation process that will ensure appropriate levels of protection under the prevailing circumstances.*" In planned exposure situations the dose term dose constraint is used, and in emergency and existing exposure situations it is called reference level.

The Expert Group on Occupational Exposure (EGOE) of the NEA Committee on Radiation Protection and Public Health (CRPRH), following its mandate to broadly identify and scope out issues in occupational radiation protection across many sectors, focusing primarily on the nuclear power sector, was charged by the CRPPH to study the current use of dose constraints in the management of occupational exposures in practice, and their implementations in regulatory frameworks. In order to reflect as closely as possible the intended meaning and the use of dose constraints in optimisation of radiation protection, particularly of occupational exposure, this publication has been prepared in close co-operation with the ICRP Working Party on the Application of the Commission's Recommendations to Occupational Exposure.

The publication is primarily, but not exclusively, directed to operators in the nuclear industry, registrants and licensees in facilities and activities, relevant authorities in other sectors outside the nuclear industry, and also to regulators responsible for adopting and enforcing respective regulations and guides. This work focuses on occupational radiation protection and does not address the uses and applications of the dose constraint concept in protection of the public or the environment.

II. SCOPE

The publication primarily addresses relevant aspects associated with the use of dose constraints in occupational radiation protection by:

- analysing experiences with interpretation and implementation of dose constraints in occupational radiation protection and in regulatory and operational frameworks following the ICRP Publ. 60;
- discussing operational and regulatory issues that may arise with the implementation of dose constraints as described in ICRP Publication 103; and
- providing suggestions regarding operational objectives and uses of dose constraints in light of recommendations in the ICRP Publication 103.

III. DOSE CONSTRAINTS IN THE LIGHT OF THE ICRP CONCEPT

For all activities that are justified, a prime radiological protection consideration is the radiation protection under the prevailing circumstances, such that resulting exposures are as low as reasonably achievable, economic and social considerations being taken into account (ALARA). To assist in the planning of optimised protection in planned exposure situations, the ICRP recommends the use of dose constraints. Broadly, a dose constraint is a value below which it should be planned to keep all doses. The dose constraint is associated with a particular "source", and should not be interpreted as a dose limit. Choosing the numerical value of a constraint for a particular source is not a simple task, and requires knowledge, experience and a thorough consideration of either the source in the particular planned exposure situation or a set of similar sources (generic dose constraint).

The ICRP introduced, in ICRP Publ. 60, the new concept of a constraint to dose or risk. This was introduced as an individual-related criterion, to be applied to a single source in order to ensure that dose or risk limits are not exceeded. A dose constraint would therefore be set at a fraction of the dose limit as a boundary in the optimisation of radiation protection from that source.

In 1996, the NEA issued a joint report with the European Commission entitled "Considerations on the Concept of Dose constraints" (NEA, 1996) which discusses the role and scope of application of the concept of dose constraint for different types of practices and exposure situations. The report also examines the meaning and the function of the various levels used in practical radiation protection and their application to the cases of occupational, public and medical exposures. It concludes that dose constraints may be a useful tool for improving optimisation in practical radiation protection, and underlines that dose constraints should not be misinterpreted and misused as a new category of limits. As for practical application of the concept of dose constraints the report highlights the fact that in many sectors, especially in industry and in the medical field, a structured optimisation approach, explicitly taking into account economic and social considerations, should be used, and the effectiveness of dose constraints depends on their adequately matching the sources to which they apply.

The principle of optimisation and role of dose constraints was further elaborated by ICRP in Publication 101 (ICRP, 2006).

Paragraph 20

"The principle of optimisation of radiological protection is defined by the Commission as the source-related process to keep the magnitude of individual doses, the number of people exposed, and the likelihood of potential exposure as low as reasonably achievable below the appropriate dose constraints, with economic and social factors being taken into account."

Furthermore, it explains that the process of optimisation below a constraint should be applied whatever the exposure situation – planned, emergency, or existing, i.e. including occupational exposures. In addition, the use of dose constraints in optimisation of protection is intended to satisfy the equity of distribution of exposure among a group of concerned individuals. In practice, each utility or operator defines a concerned group based on similar job scopes or functions.

Paragraph 21

"It is not possible to give a simple formal definition of a single source or of the total group of relevant sources. In the application of optimisation below constraint, the term 'single source' should be used in a broad sense, such as the x-ray equipment in a hospital, or the release of radioactive materials from an installation. Most situations will give rise to a predominant source of exposure for any single individual, or representative person, making it possible to treat sources separately when considering actions. Provided that the operating management and the regulators both apply the Commission's broad policies, the definition of a single source is straightforward. Difficulties will arise if the policy is distorted, e.g. by artificially subdividing a source in order to avoid the need for protective action, or by excessively aggregating sources to exaggerate the need for action."

Equity of distribution of exposure among a group of concerned individuals is an attribute to be considered in the forward-looking iterative process of optimisation. A further item for consideration is defining the groups of individuals within which equity is to be evaluated.

Paragraphs 46

"Additional aspects to be considered in the comparison of protective options are the social values, particularly equity in the distribution of exposure among the concerned group of individuals. For example, different protective options for a group of workers may be characterised by similar average individual and collective doses but rather different profiles of the dose distribution. In such a comparison, equity considerations will, in most cases, lead to protective options with the highest individual exposures being discarded.

Paragraphs 47

"For occupational exposure situations, information about individual doses to workers is accessible in most cases, and assessment of the individual dose distribution is relatively easy. For public exposure situations, information about individual doses is generally not directly accessible and these can only be estimated using surrogates. For example, modelled average individual doses can be estimated for different subgroups exposed to a given source. For such an approach, it is necessary to define the place inhabited (distance from the source), age and gender distribution, and living habits (diet, types of recreation) for each group of exposed individuals. If necessary, it is also possible to estimate the evolution of exposure in time for each group for the current and future generations."

Prospective estimation and assessment of doses at a facility being designed or being substantially modified may need to strongly consider available information from facilities of similar type already in operation and using a day-to-day management programme for effective control and reduction of doses to

workers. Additionally, workers in mechanical maintenance, electrical maintenance, radiation protection or other work groups at a reactor site may for example be defined as groups within which equity of dose distribution is to be evaluated. (That is, equity may be evaluated within groups of individuals who do similar types of work.) Perhaps the most difficult groups to evaluate are those groups whose individual members work at multiple reactor sites during the year, for example, performing highly specialised refuelling tasks. The process of optimisation is to consider protective options relevant to each group of workers.

The role of optimisation has been further strengthened in ICRP Publ. 103 by stating that "Re-enforcing the principle of optimisation of protection, which should be applicable in a similar way to all exposure situations, with restrictions on individual doses and risks, namely dose and risk constraints for planned exposure situations and reference levels for emergency and existing exposure situations.", and by clarifying more closely of the role of optimisation and position of dose constraint in it. The ICPR Publ. 103:

- strengthens the principle of optimisation by focusing on (constrained) optimisation below dose constraint: "*Constraints provide a desired upper bound for the optimisation process*";
- clarifies the function of dose constraint as not being misunderstood as a lower bond for optimisation: "*it is not relevant to determine, a priori, a dose level below which the optimisation process should stop*";
- provides guidance without setting the value of the dose constraint for a particular task or situation: "*Depending on the exposure situation, the best option could be close to or well below the appropriate source-related constraint or reference level.*"; and
- introduces recommended bands of dose constraints.

Along with this approach, the process of optimisation with the use of dose constraints (or reference levels) is applied in planning protective actions and in establishing the appropriate level of protection under the prevailing circumstances. The doses are then compared with the dose constraint which is understood as a prospective and source-related restriction on the individual dose from a source.

Key elements relevant to dose constraints, as given in ICRP Publ. 103 are the following:

Glossary definition of dose constraint

"*A prospective and source-related restriction on the individual dose from a source, which provides a basic level of protection for the most highly exposed individuals from a source, and serves as an upper bound on the dose in optimisation of protection for that source. For occupational exposures, the dose constraint is a value of individual dose used to limit the range of options considered in the process of optimisation. For public exposure, the dose constraint is an upper bound on the annual doses that members of the public should receive from the planned operation of any controlled source*."

Paragraph 216

"*In all situations, the process of optimisation with the use of constraints or reference levels is applied in planning protective actions and in establishing the appropriate level of protection under the prevailing circumstances. The doses to be compared with the dose constraint or reference levels are usually prospective doses, i.e., doses that may be received in the future, as it is only those doses that can be influenced by decisions on protective actions. They are not intended as a form of retrospective dose limit.*"

Paragraph 225

"*The concepts of dose constraint and reference level are used in conjunction with the optimisation of protection to restrict individual doses. A level of individual dose, either as a dose constraint or a reference level, always needs to be defined. The initial intention would be to not exceed, or to remain at, these levels, and the ambition is to reduce all doses to levels that are as low as reasonably achievable, economic, and societal factors being taken into account.*"

Paragraph 226

"*For the sake of continuity with its earlier Recommendations (ICRP, 1991b), the Commission retains the term 'dose constraint' for this level of dose in planned exposure situations (with the exception of medical exposure of patients). For emergency exposure situations and existing exposure situations, the Commission proposes the term 'reference level' to describe this level of dose. The difference in terminology between planned and other exposure situations (emergency and existing) has been retained by the Commission to express the fact that, in planned situations, the restriction on individual doses can be applied at the planning stage, and the doses can be forecast so as to ensure that the constraint will not be exceeded. With the other situations a wider range of exposures may exist, and the optimisation process may apply to initial levels of individual doses above the reference level.*"

Furthermore, in terms of selecting a numeric value for dose constraint in planning of optimised protection for a particular source, the ICRP provides the following recommendations:

Paragraph 256

"*The Commission continues to recommend that occupational exposure in planned exposure situations be controlled by the procedures of optimisation below a source-related constraint (see Section 5.9.1) and the use of prescriptive dose limits (see Section 5.10). A constraint should be defined at the design stage of a planned exposure situation for its operation. For many types of work in planned exposure situations, it is possible to reach conclusions about the level of individual doses likely to be incurred in well-managed operations. This information can then be used to establish a dose constraint for that type of work. This work should be specified in fairly broad terms, such as work in industrial radiography, the routine operation of nuclear power plants, or work in medical establishments. However, there may also be more specific situations where a constraint can be established to guide particular activities.*"

Paragraph 257

"*It will usually be appropriate for such dose constraints to be set at the operational level. When using a dose constraint, a designer should specify the sources to which the constraint is linked so as to avoid confusion with other sources to which the workforce might be concurrently exposed. The source-related dose constraint for occupational exposure in planned situations should be set to ensure that the dose limit is not exceeded (see Section 5.10). Experience gained in managing workers exposed to radiation will inform the choice of a value for a constraint for occupational exposure. For this reason, large established organisations, having a comprehensive radiological protection infrastructure, will often set their own constraints for occupational exposure. Smaller organisations with less relevant experience may require further guidance on this topic from the appropriate expert bodies or regulatory authorities. Nevertheless, the overall responsibility for setting constraints lies with those who are responsible for worker exposure.*"

As can be seen from the quoted ICRP paragraphs above, dose constraints for occupational exposure should be established for each source as appropriate. This publication primarily addresses national regulatory approaches and actual practices in the area of nuclear energy. Again, the use of dose constraints in public exposure is not included within the Scope of this work. The conceptual difference in use of dose

constraints in occupational and public areas is that responsibility for their use lies with the operator in the former, while it lies with the regulatory authorities in the latter.

IV. DOSE CONSTRAINTS IN INTERNATIONAL AND NATIONAL REGULATIONS

The process of optimisation of radiation protection using dose constraints, operational experience and other occupational radiation protection instruments as tools, is expected to result in a radiation protection system that not only satisfies compliance with dose limits, but also keeps doses as low as reasonably achievable. When using dose constraints in an optimisation process, there is a need to consider the following questions, which are of two categories – general and specific:

General questions on principles of use of dose constraints:

- What benefits can be expected from the use of dose constraints in an optimisation process?
- Are dose constraints used by an operator as a regulatory instrument?
- Who manages performance against dose constraints and other occupational radiation protection criteria?
- In what context are dose constraints set: for sites (refers to design) or for tasks (refers to operation)? How are dose constraints fixed, implemented and controlled in each of these cases?
- Can dose constraints become a new "standard of care" for workers, or misinterpreted as a "second and lower dose limit" that triggers a de facto unwarranted reduction of the annual dose limits?
- How are dose constraints for occupational radiation protection balanced with the management of other work place risks? What guidance is there or should there be on this issue?
- How would the concept of a dose constraint be applied for individuals occupationally exposed to multiple sources in the course of a year, potentially with those sources being in different countries?

Specific questions on practical aspects associated with use of dose constraints

- Who sets a dose constraint (utilities and/or authorities), and in what situations?
- How are dose constraints set and how are their uses described?
- May dose constraints reasonably be set on a generic basis for a set of sources (e.g., a company's fleet of reactors or a country's fleet of reactors)?
- Are there means to adjust dose constraint for particular circumstances of a single source (e.g., a specific nuclear power reactor or a nuclear power plant (NPP) site)?
- Are only individual doses or may collective doses and/or dose distributions also reasonably be used/considered in a constraint-setting process?
- May dose constraints reasonably be readjusted after an optimisation process is completed?

- Can the use of individual dose constraints result in higher collective doses? If yes, what are the limitations or guidelines on the balance of the two types of dose?

In order to address some of the above issues, and to collect information as to how dose constraints are used in regulatory practice in countries and what is their role, two surveys were performed and results are elaborated in this Section. Detailed answers are shown in Appendices 1 and 2 where available:

- Survey carried out by the European Radiation Protection Authorities Network (ERPAN)[1] in April 2010 on how dose constraints, as defined in the EU Directive are applied in the non-nuclear energy sector across Europe.
- Survey carried out by the Information System on Occupational Exposure (ISOE) on how dose constraints or constraint-like concepts are applied in the nuclear energy sector.

International BSS

In terms of implementing the recommendations of the ICRP into a regulatory framework it is necessary:

1) to establish appropriate requirement(s) for optimisation of radiation protection for a particular source, and

2) to clarify the role of dose constraints in the process of the optimisation.

The International Basic Safety Standards (IAEA, 1996) (BSS-1996 edition) requires that both – protection and safety shall be optimised; and that doses received by an individual be subject to dose constraints:

1) Required optimisation

The requirement for optimisation and for constraining of doses from a particular source is introduced in paragraph 2.24, which directly links optimisation and dose constraints: "*In relation to exposures from any particular source within a practice, except for therapeutic medical exposures, protection and safety shall be optimised in order that the magnitude of individual doses, the number of people exposed and the likelihood of incurring exposures all be kept as low as reasonably achievable, economic and social factors being taken into account, within the restriction that the doses to individuals delivered by the source be subject to dose constraints.*"

And specifically, the optimisation of radiation protection in occupational exposure is explicitly required in paragraph I.4(b) "*occupational protection and safety be optimised in accordance with the relevant principal requirements of the Standards*".

2) Dose constraints

The use of dose constraints in optimisation for all exposures, except medical, is required according to paragraph 2.26 "Except for medical exposure, the optimisation of the protection and safety measures

1. The European Radiation Protection Authorities Network was established in 2006 in order to promote the sharing of information and experiences among regulatory authorities across Europe. The network is comprised of individuals from regulatory authorities, both within and outside the European Union, who are directly responsible for the management of regulatory activities including authorisation, inspection and enforcement programmes within their respective organisations. It focuses on activities in the non-nuclear sector and consists of representatives of 19 regulatory authorities across 17 European countries.

associated with any particular source within a practice shall be subject to dose constraints …", and this paragraph further elaborates on setting its value as guaranteeing that dose limits will not be exceeded during operation of the source or as a result of release of radioactive substances to the environment.

European Countries

All member states of the European Union are required to enact the requirements of the EU Directive into national legislation. While the development of such national legislations should result in consistency and harmony in the approaches to regulating ionising radiation across the European Union, including for example how the concept of dose constraints are applied, in practice variations in how dose constraints are mentioned in the national regulations results in different approaches across EU member states.

These variations in approaches to how dose constraints are applied are not surprising given that the EU Directive merely states that "*dose constraints should be used, where appropriate, within the context of optimisation of radiological protection*". Furthermore it states that "*guidance established by each Member State on the appropriate procedures to be applied to individuals exposed in accordance with Article 6(4)(b)-comforters and carers, and (c)-research volunteers, may include dose constraints*".

The results of the ERPAN survey (Appendix 1) show that the majority of European countries have adopted the concept of dose constraints or similar instruments in the non-nuclear energy sector in their national legislation by implementing the EU Directive. These results also include some countries not in the European Union. In analysing the survey, it can be seen that there is no consistency in the terminology used with some countries using dose constraints, while others use source related dose values, dose levels or other instruments. Clearly, there can be observed inconsistencies in approaches as well as terminologies. Similarly there are different approaches as to whether the regulator or facility sets dose constraints, or whether it's a joint decision making process. Finally, in some countries they are applied to a particular source, being either generic or specific in value, whereas in other countries they are applied to a particular work activity. Collated questions and answers of the survey are shown in Appendix 1.

Summaries describing the application of dose constraints in several European countries, either in general or for the non-nuclear energy sector[2], and also for nuclear energy sectors where available, are given below.

Belgium

The EU Directive has been transposed into Belgian law by the Royal Decree of 20th July 2001 on the protection of workers, public and environment against the hazards of ionising radiation (Royal Decree, 2001). The regulations provide for the regulatory authority to set dose constraints in the context of optimisation of protection of workers, members of the public and the environment. They can either be generic in value for radioactive sources or activities involving the use of ionising radiation or else specific and included on the details of a licence issued to a facility. In the context of occupational protection they would be used in the operational phase rather than the design phase if the concepts were implemented. To date, dose constraints have only been used for determining the release limits, both liquid and gaseous, for radioactive materials for major nuclear installations and have not been applied outside the nuclear energy sector. The Belgium regulatory authority is considering introducing generic dose constraints in the non-destructive testing sector in the future.

2. Based on results of the survey carried out by ERPAN (Appendix 1).

Czech Republic

As a part of the optimisation of radiation protection, all exposures shall be planned and kept as low as reasonably achievable, taking into account economic and social factors. The variants of radiation protection assessed as a part of the optimisation of radiation protection shall not lead to exposure which exceeds the exposure limits or the dose constraints if these limits and dose constraints are laid down. If dose constraints for particular radiation practices or a particular source of ionising radiation are to be set out, the State Office for Nuclear Safety (SUJB) shall take into account all existing experiences of similar radiation practices and handling of the sources so that the level of radiation protection shall not be lower than achieved in practice up to date. The SUJB shall also consider a possible effect of the other activities and sources to avoid exceeding the limit.

For public exposure, the dose constraint is an upper bound of the annual dose that members of the critical group of the public could receive from a discharge of radioactive substances into environment.

The system of reference levels is established and required by current legislation. The reference levels shall be defined in the monitoring programme (recording, investigation and intervention levels), which is approved document by the regulatory body.

The recording level shall separate the values being worthy of attention from insignificant ones. The recording level shall usually be defined as one tenth of limit. Monitoring methods shall be chosen in such a way that the minimum detectable level of a radiation protection quantity measured shall be lower than the recording level defined in this way.

The investigation level shall usually be defined as three tenths of the limit or as the upper bound of normally monitored values. Exceeding of this level shall lead to a consecutive investigation of causes and possible consequences of the deviation of monitored quantity. The meaning of investigation level is interpreted to be close to that of the dose constraint. The investigation level for occupational exposure is set up for one month (usually around 1 mSv) and for one year (around 6 mSv). The idea now is that the dose constraint could be understand as an upper value of annual investigation levels and could be set up for most professions on the level around 10 mSv.

The intervention level is such a level for which its exceeding shall introduce the remedial measures to change the deviation of a quantity monitored. The interventions and decisive procedures shall be specified exactly in the monitoring programme. More than one intervention level may be defined for a particular quantity which corresponds to interventions more and more significant depending on a rising significance of the deviation of monitored quantity.

France

In France the term dose constraint is not explicitly used in legislation, though the concept of optimisation is clearly included. Optimisation of radiation protection of the employees, public and the environment must be considered at all stages (design, operation etc). Despite of not using the term dose constraints in legislation, licensees use relevant administrative dose limits even if they do not call them dose constraints. However, they are neither a regulatory limit, nor a dose constraint, as stated in ICRP Publ. 103.

The Article R.4451-11 of the French Labour Code (Code du Travail, 2010) makes references to a "dose objective" stating that "*radiation protection officer ('personne competente en radioprotection') shall establish dose objectives for individual and collective doses for a given set of tasks, contributing to the same goal at the same place. These dose objectives must be established at a level as low as possibly achievable taking into account the available techniques and the nature of the operation…. and in any case*

at a level not exceeding the dose limits." The regulations are clear that the obligation is on the employer to set dose objectives at a level as low as possible. In practice, numerical values are set by the operator and are reviewed by the regulator when the authorisation is issued and at subsequent regulatory inspections.

Germany

In the non-nuclear energy sector Germany does not use the term dose constraint or any equivalent translations in its official radiation protection regulations. Apart from dose limits there are no other restricting dose values in the German radiation protection ordinance and x-ray ordinance.

The application of the optimisation principle is obligatory with the requirement to keep exposures as low as reasonably achievable taking social and economic considerations into account. In many cases there are also other occupational health and safety rules and measures or product safety requirements which take complementary effect in exposure reduction. Further restrictions in the sense of introducing dose constraints are presently not considered as added value.

In the nuclear energy sector, and in particular in NPPs there are numerous operational and in-plant dose values to ensure that official dose limits remain undercut (e.g. maximum permissible daily or monthly doses, dose shares for internal and external exposure, etc. for individual workers and, where appropriate, also for collectives). All dose-related criteria are not identical with dose constraints in a literal sense; they have different targets and are used as thresholds that trigger internal actions when exceeded.

Most important in this context and binding for all NPPs is the Guideline IWRS-II (GMBl, 2005). The guideline applies to the specification and implementation of radiological protection measures for planned activities in relation to maintenance, modification, decommissioning or dismantling of nuclear facilities and installations.

The Guideline does not explicitly use the term dose constraint or any synonymic translation. Instead, it sets dose levels as decision criteria for the required radiation protection procedures in a planned exposure situation. When it is ensured that the planned exposure from a specific task will remain under the required dose criteria then the work can be executed with a defined "Routine Radiation Protection Procedure". However, if these dose criteria could reasonably be anticipated to be exceeded then an extensive "Special Radiation Protection Procedure" has to be applied. The decision as to which the radiation protection procedure is determined by the Radiation Protection Officer and depends on the result of the anticipated exposure of the planned work.

The Routine Radiation Protection Procedure includes:

- technical configuration and issuing of work order;
- review of work order by radiation protection officer and specification of the radiological protection measures;
- confirmation of work order by radiation protection officer;
- preparation of radiological protection measures before commencing the activity;
- specification of additional radiological protection measures if necessary;
- radiological protection clearance;
- implementation of radiological protection measures during the work;
- reporting on the completion of the work;
- cancellation of the radiological protection measures;

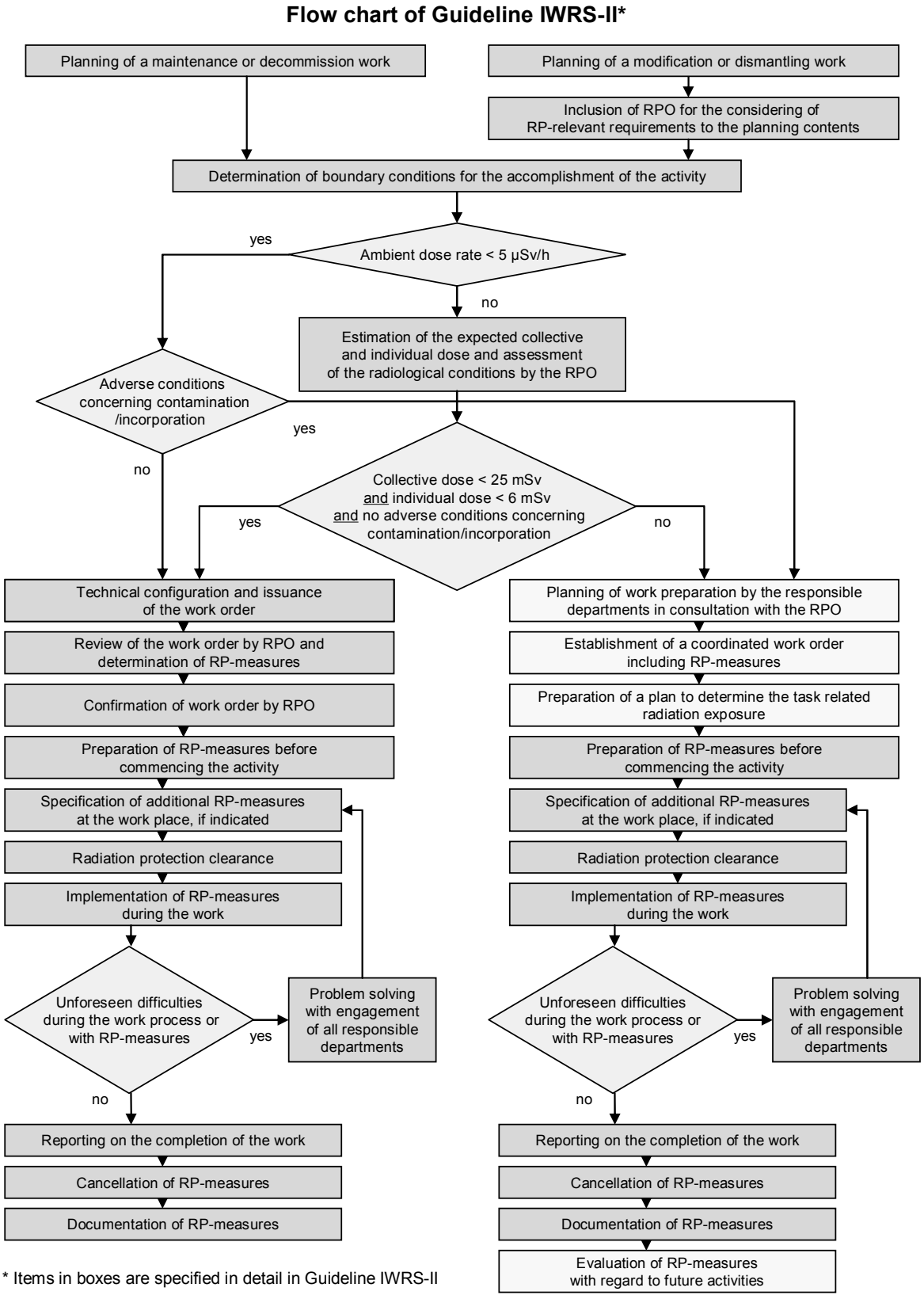
- documentation of radiological protection measures.

The Special Radiation Protection Procedure is more extensive. It follows in principle the Routine Radiation Protection Procedure but requires in particular:

- planning of work preparation by the responsible departments in consultation with the radiation protection officer;
- establishment of a co-ordinated work order including radiological protection measures;
- preparation of a plan to determine the task related to radiation exposure;
- preparation of radiological protection measures before commencing the activity;
- specification of additional radiological protection measures if necessary;
- radiological protection clearance;
- implementation of radiological protection measures during the work;
- reporting on the completion of the work;
- cancellation of the radiological protection measures;
- documentation of radiological protection measures;
- evaluation of the radiation protection measures with regard to future activities.

The flow chart of the decision process for the application of the routine or special radiation protection procedure is shown in Figure 1.

Figure 1. Flow chart of Guideline IWRS-II



The application of the special radiation protection procedure does not necessarily mean that the dose criteria are met after the work is accomplished, but it reveals potential gaps between work planning and execution and thus room for improvement.

Beside the guideline-based dose criteria of IWRS-II, every NPP uses additional dose guidance levels for work planning on a daily, monthly or annual base. These dose guidance values are site specific and set by the radiation protection officer. They apply both to employees and where applicable also to contractors.

Greece

Dose constraints are mentioned in paragraphs 1.1.3b, 1.4 and 1.9 of the Greek radiation protection regulations (Official Gazette, 2001). They are defined as dose levels designed to limit the expected and potential exposures arising from a defined practice or defined source in the context of a practice. The levels are used at the radiation protection planning stage for optimisation purposes and are either laid down in the regulations or approved as the case may be by the Regulatory Authority (GAEC). In relation to occupational exposure they are applied in the totality of the practices implementing exposure to ionising radiations.

For all approved practices or activities, the regulatory authority lays down general dose constraints for the protection of the public and workers. Moreover, for each source, in the context of a practice or activity, the radiation protection officer for the facility shall lay down special dose constraints at the planning stage, which shall be approved by the regulatory authority.

Ireland

The EU Directive is implemented in Irish legislation by the Radiological Protection Act (Radiological Protection Act, 1991). The legislation defines a dose constraint as "*a restriction on the prospective doses to individuals, which may result from a defined source, for use at the planning stage in radiation protection whenever optimisation is involved*" – this definition is taken directly from the EU Directive. Dose constraints are generally regarded as advisory and, while not having the legal force of a dose limit, are the values that must be used in the planning stage for a new facility. Accordingly, all applicants applying to the regulatory authority in Ireland – Radiological Protection Institute of Ireland (RPII) for a new licence in respect to a proposed facility must demonstrate how their design and shielding specification complies with the dose constraints in consideration of all the likely pathways that could result in exposures to workers or members of the public.

The dose constraint for an exposed worker is set by the regulatory authority at 1 mSv/y and must be used in the design of any new facility in Ireland. In addition to their application to new facilities, they are also used in situations where existing facilities are being upgraded or modified or when new equipment is being installed in existing facilities.

In Ireland the dose constraint is an optimisation tool to be used at the design stage of any new facility in order to ensure that any potential doses to workers will be significantly below the occupational dose limits. However, once the facility has been built, and sources of ionising radiation are acquired, the only enforceable limits/values that the undertaking must adhere to are the dose limits set out in legislation, i.e. the dose constraint values are not enforceable once the facility becomes operational.

However, in the conditions attached to each license issued by the RPII there is a requirement that licensees must carry out all practices in such a manner that working conditions are optimised and, consequently, exposures are kept as low as reasonably achievable. In the case of exposed workers, the license conditions explicitly require the licensee to investigate any practice, which, in any continuous sixteen-week period, has given rise to doses equal to or greater than the following investigation values:

- Effective dose 2 mSv
- Dose to lens of the eye 15 mSv
- Dose to skin, hands, forearms, feet or ankles 50 mSv

Luxembourg

The concept of a dose constraint appears in Article 5.1.6 in the national radiation protection regulation which implements the EU Directive. It stipulates that the competent authority may define dose constraints within the authorisation in order to optimise radiation protection. Dose constraints are defined as a dose restriction related to a source, a practice or a task. In practice dose constraints are not used as a regulatory tool in Luxembourg. (Grand-ducal regulation of 14 December 2000, 2000)

Norway

The concept of a dose constraint only appears in the national radiation protection regulations (Act and Regulations on Radiation Protection and Use of Radiation, 2000) in the context of optimising the radiation doses received by non-radiation workers and the general public, as a result of activities involving ionising radiation such as those found in medical and industrial applications. A dose constraint of 0.25 mSv/y is given for non-radiation workers and the general public in Article 16 of the regulations, but there is no similar value given for occupationally exposed workers.

Slovenia

Dose constraints are included in the Ionising Radiation Protection and Nuclear Safety Act (Official Gazette of Republic of Slovenia, 2002 and 2004) which implements the EU Directive. The regulations state that they are to be used in the planning of the optimisation of protection against ionising radiation. Dose constraints can either be “authorised” or “operative” for either practices or for specific sources. In the case of authorised values the regulatory authority sets them based upon measurements of actual doses received, either individual or collective, from existing radiation protection practices with comparable working conditions and based upon comparison with estimated doses received after the introduction of additional protection measures. For the operational values, an authorised radiation protection expert within each licensee must determine the values to be used, based upon doses rates, workloads etc, and these have to be formally recorded in “Evaluation of the protection of exposed workers against radiation”, a document, which must be produced by each licensee.

Spain

The concept of dose constraints appears in Article 6 of the Royal Decree 738/2001 (Spanish Official State Gazette, 2001), which approves the Regulation on Health Radiological Protection against Ionising Radiations. This article states that dose constraints must be used, where appropriate, within the context of optimisation of radiation protection, taking into account the recommendations of the national regulatory authority, Nuclear Safety Council (CSN). These dose constraints must be assessed and approved by CSN.

Outside the nuclear energy sector they are only applied to workers in industrial radiography facilities in order to promote the optimisation of radiation protection. They are set by the Spanish Regulatory Authority through consensual agreement with the qualified expert of the facility for specific tasks and practices. The values agreed must then be included as reference values in the operation manual of the facility with which all workers must comply. Adherence to these reference values is mandatory and penalties can be imposed where these values are exceeded.

Sweden

The term dose constraint does not appear explicitly in the Swedish national regulations which implement the EU Directive (Riksdagen, 1998). However the concept does exist in separate regulations issued by the regulatory authority (SSM). For the design of new diagnostic or therapeutic facilities in the medical and veterinary sectors, the regulations require the shielding in the proposed facility to meet a dose constraint of 0.1 mSv in order to optimise the protection of workers and members of the public (SSM, 2008a). For certain equipment or work activities the regulations also provide for an instantaneous dose rate limit, based upon the relevant dose limit, to be set by the regulatory authority. In these cases the licensee must define local rules where he can choose to use these constraints (SSM, 2008b). In practice these are called limits and are treated as such by the regulatory authority.

Switzerland

In Switzerland a modified concept of a dose constraint is used in the national regulations (Ordonnance sur la radioprotection, 1994). It is referred to as a source related dose value. This dose value is used both at the design and operational stages and is applicable to workers, members of the public and the environment. There are no general values specified in the regulations; however, the regulatory authority can define a specific value for a company if necessary.

In addition, the regulations also include notification thresholds for doses received by occupationally exposed persons (Article 49) during the course of their work. This states that *"if the effective dose determined over the monitoring period is greater than 2 mSv or the equivalent dose to an organ is greater than 10 mSv, this must be reported by the personal dosimetry laboratory to the licence holder and to the competent supervisory authority no later than ten calendar days after receipt of the dosemeter"*. Upon being notified of the occurrence of a reportable dose the competent supervisory authority requires the facility/worker to complete a questionnaire detailing the explanation for how the dose was received and setting out optimisation measures to reduce the chances of a recurrence. This approach ensures that the worker is fully aware of his/her accumulation of doses or is reminded of a work practice that gave rise to such an elevated dose. This approach has worked well as it alerts the competent supervisory authority, the facility and worker of potential non-optimised work practices long before any dose limits are reached and provides for further optimisation to be considered and implemented.

United Kingdom

The concept of dose constraint is included in the Ionising Radiations Regulations 1999, Statutory Instrument 3232 (Stationery Office, 2000) which gives effect to the EU Directive in the UK. Reg 8(3) states that *"where it is appropriate to do so at the planning stage of radiation protection, dose constraints shall be used in restricting exposure to ionising radiation pursuant to paragraph (1) (ALARP requirement)*". In the UK a dose constraint is an upper level of individual dose specified by the employer for use at the design or planning stage. It is one of many tools for helping to restrict individual exposures as far as reasonably practicable. Dose constraints may be used to consider the best plan or design for an individual task or event or the introduction of a new facility. However, they are not intended to be used as investigation levels once a decision has been taken about the most appropriate design or plan.

Dose constraints are not required for all types of situations which could give rise to occupational exposure and the need to establish dose constraints is best determined as part of the risk assessment process. Further guidance on the application of dose constraints is provided which states that "*Dose constraints for occupational exposure are only likely to be appropriate where individual doses from a single type of radiation source will be a significant fraction of the dose limit (i.e. at the rate of a few mSv a*

year)" (HSE, 2000). Dose constraints are not likely to be appropriate for occupational exposures resulting from the following types of work with ionising radiation where employee doses tend to be low:

- diagnostic radiology, nuclear medicine, most radiotherapy and other medical exposures;
- most work in the non-nuclear industrial sectors, and
- teaching and most research activities,

The main exception would be for special types of work (e.g., some interventional radiology), where effective doses are likely to be more than a few mSv a year.

Even in specialised areas, such as industrial radiography, where individual doses are sometimes relatively high, it may not be appropriate to establish dose constraints for planning individual jobs unless adequate dose information is available for that type of work. If the radiation employer has such information, it should be feasible to choose a dose constraint which is representative of a well-managed operation, for example radiography of steam tubes during a conventional power station outage."

Regulation 7 of IRR99 also sets out a dose investigation level: "Every employer shall, for the purpose of determining whether the requirements of paragraph (1) [employer must take all reasonable steps to restrict exposure to ionising radiation] are being met, ensure that an investigation is carried out forthwith when the effective dose of ionising radiation received by any of his employees for the first time in any calendar year exceeds 15mSv or such other lower effective dose as the employer may specify, which dose shall be specified in writing in local rules made pursuant to Regulation 17(1) [local rules] or, where local rules are not required, by other suitable means."

Northern America

Canada

According to the Canadian Nuclear Safety Commission (CNSC) legislation, except the compliance with dose limits, the license must have established an action level – paragraph 3(1)(f) of the General Nuclear safety and Control Regulations (Canada Gazette Part II, 2000), which requires that an application for a CNSC license contain "*any proposed action level for the purpose of section 6 of the Radiation Protection Regulations*" (Radiation Protection Regulations, 2000).

The Radiation Protection Regulations in section 6(1) define action level as "a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection programme and triggers a requirement for specific action to be taken."

In section 6(2) it further states: "When a licensee becomes aware that an action level referred to in the licence for the purpose of this subsection has been reached, the licensee shall

- *conduct an investigation to establish the cause for reaching the action level;*
- *identify and take action to restore the effectiveness of the radiation protection programme implemented in accordance with section 4; and*
- *notify the Commission within the period specified in the licence*."

By this, the action level is not an equivalent of dose constraint, and it is a level (below limit) which, if reached, triggers a certain action to secure compliance with limit, and it is enforced by regulator.

U.S.A.

According to radiation protection policy and principles, the process of optimisation of radiation protection using dose constraints (or other instruments for optimisation of radiation protection) and operational experience as tools is expected to end up with a radiation protection system that not only satisfies compliance with dose limits, but also keeps doses as low as reasonably achievable.

The USNRC's Standards for Protection Against Ionising Radiation in Part 20 of Title 10 of the *Code of Federal Regulations* define the terms "constraint" (dose constraint) as a value above which specified licensee actions are required, and "limits" (dose limits) as the permissible upper bounds of radiation doses (Ref. 1). The existing USNRC regulatory framework includes various requirements for controlling exposures to workers and individual members of the public. These requirements have been implemented by a variety of regulatory mechanisms, including incorporation in regulatory standards and license conditions for facility operation, over the course of many years. Although some of these requirements function in a manner similar in concept to the ICRP Publ. 103 definition of dose constraints, they were not developed as dose constraints, and in most cases are considered as limits.

USNRC requires licensees to use procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses that are ALARA (Ref. 2). For occupational exposures, many USNRC licensees in the nuclear power industry are familiar with the dose constraint concept and voluntarily use planning values to ensure compliance with annual dose limits and dose goals for short-term tasks as part of their ALARA programme. In the U.S.A., the use of planning values is not as rigorous in many industrial, academic, medical and research activities. The USNRC regulations do not currently require the use of dose constraints for occupational radiation protection ALARA programmes, and thus their use is voluntary and variable amongst different categories of USNRC licensees.

The U.S. Department of Energy (USDOE) has its own set of radiation protection regulations and directives for controlling occupational and public doses at defence-related, scientific and environmental restoration facilities (Ref. 3). For occupational exposures, USDOE requirements include design objectives that limit external exposures to 10 mSv/y (Ref. 4). Design objectives for internal exposure are to avoid releases of airborne radioactivity to the workplace and to control inhalation of radioactivity ALARA through the use of ventilation and confinement (Ref. 5). Also, USDOE established an administrative control level of 20 mSv/y that requires administrative approval for a higher occupational dose limit (Ref. 6). In addition, design criteria for the construction of new USDOE facilities limit occupational doses to 10 mSv/y. For public exposures, the USDOE application of dose constraints is consistent with the USNRC approach, but there are differences in the use of the terms "constraint" and "limit."

Asia

Japan

The Radiation Council is an advisory panel to the Government established in order to maintain consistency with technical standards among the radiation protection regulations in Japan. The Council's committee on the basic safety policy issues (the Basic Committee) established to investigate scientific and fundamental issues concerning radiation protection commenced discussions in 2008 on the implementation of ICRP 2007 recommendations in national regulations. The Basic Committee also completed examination whether dose constraints in occupational exposure shall be introduced into the existing regulations, as one of the issues in the implementation of ICRP 2007 recommendations. Based on this discussion the Basic Committee proposed in January 2011, a solution of the issue as follows:

The current status shows that the observance of the dose limit, i.e. keeping the dose to radiation workers below the dose limit, has been sufficiently achieved by the implementation of the strategy of the dose management for the workers based on the existing regulations. This suggests that uniform introduction of dose constraints in occupational exposure into the current regulatory system impedes the flexible and optimum management conducted by individual facilities. Therefore, it is not necessary to introduce the dose constraints into national regulatory system in which the dose limit has already been introduced.

Such proposal was further supplemented with the following explanations based on the current status of the radiation protection management, which is conducted by individual facilities, as well on the current regulatory system:

In Japan, a dose management for radiation workers has been regulated as a strategy to reliably achieve the observance of the dose limit by keeping the dose to radiation workers below the dose limit.

Compared to the dose limit, which is designated as a concept of individual-related restriction, the dose constraint is designated by ICRP as a concept of source-related restriction. It is used in the optimisation process for radiation protection as a strategy in order to keep any exposure as low as reasonably achievable, social and economic factor being taken into account. The strategy that set this dose constraint for each source is considered to be useful as a strategy to persist in the observance of the dose limit.

The existing regulations in Japan prescribe the upper dose of 1 mSv/week for radiation workers in a controlled area as one of the design criteria for licensing. In addition, many large-scale facilities (e.g. nuclear power plants) have adopted independently flexible management as appropriate, such as a limitation of access and a designation of restricted area using the criteria of dose equivalent rate or radioactive concentration in air, and a limitation of operation time in high dose rate areas.

This kind of management, which is operated in each workplace in facilities, is based on the concept of source-related restriction, and is considered as a similar one using the dose constraint.

Compared to such large-scale facilities described above, small-scale facilities treat just a small amount of radioactive materials and their usage is not complicated. Because almost all such facilities are in sound condition to achieve the observance of the dose limit as long as the dose management for radiation workers is conducted appropriately, it is considered that such small-scale facilities do not need the same level of management as conducted in large-scale facilities.

From the considerations mentioned above, it can be recognised that the current management of occupational exposure, which is flexibly operating by individual facilities, has an equal effectiveness to that using the dose constraint to comply the dose limit, and that the uniform limitation of the management for all facilities by institutionalising the strategy using the dose constraint for each source in addition to the strategy of the observance of the dose limit, has a potential for impeding the operation of the flexibly and optimum management in each facility. The committee, therefore, concluded that it is not necessary to introduce the dose constraints into national regulatory system in which the dose limit has already been introduced.

V. DOSE CONSTRAINTS AND REVISION OF THE BASIC SAFETY STANDARDS

As described in the Chapter IV, BSS-1996 edition specifies that dose constraints need to be used in the optimisation of protection and safety measures, however it does not elaborate the issues further, nor does it state explicitly that the process of optimisation is applied in planning protective actions and that the doses, which are to be compared with dose constraints, are prospective doses. Since ICRP Publ. 103 strengthens the aspects of the use of dose constraints, the scheduled revision of the former document intends to address these issues in a coherent way.

International BSS

The revision of the BSS-1996 edition, initiated in 2006 and foreseen to be completed in 2011, addresses the issues accordingly by enforcing the role and position of dose constraints in optimisation of radiation protection. Dose constraints will remain to serve as a boundary or upper bound on individual annual doses received from a particular source, and will be used as a tool in optimisation of the protection and safety. In order to avoid potential misinterpretation of dose constraint as limit, a significant effort in the revision process is being made by carefully drafted text of relevant requirements.

In addition to the fact that the revision of the BSS-1996 edition follows, to the extent possible, the recommendations of the ICRP, it is also based on ten radiation safety principles as are introduced in the IAEA Safety Fundamentals (IAEA, 2006) The Safety principle 5 of this publication (*Optimisation of protection*) states that *"protection must be optimised to provide the highest level of safety that can be reasonably achieved.*"

In order to ensure optimisation of protection and to facilitate the setting of dose constraints, the revision of the BSS-1996 edition also intends to provide more details on recommended ranges for setting dose constraints or reference levels following ICRP Publ. 103:

- Dose constraints or reference levels below 1 mSv: to a source where there is little or no individual benefit to the individual, but for which there may be benefit to society in general;
- Dose constraints or reference levels of 1-20 mSv: individuals usually receive benefit from the exposure situation;
- Reference levels of 20-100 mSv: to sources that are not under control or where actions to reduce doses would be disproportionately disruptive;
- For any situation resulting in a dose above 100 mSv the selection of the value of reference level would be based on the characteristics of the exposure situation.

The revision of the BSS-1996 edition also extends to the establishment of dose constraints for carers and persons exposed in biomedical research. Along with these changes, dose constraints will be used in the optimisation of protection of carers (in medicine) and persons exposed in biomedical research, and dose constraints will also be required for human imaging procedures using ionising radiation, which are performed for purposes other than medical diagnosis or treatment.

Euratom BSS Directive

The concept of dose constraints has already been introduced in the current Euratom Basic Safety Standards Directive[3] (EU Directive), although the respective requirement still left some flexibility to Member States regarding its implementation into national legislation (see chapter on current practices). Triggered by ICRP Publication 103, the European Commission decided to revise the Euratom BSS and to introduce more precise requirements on dose constraints.

In accordance with ICRP Publication 103, it is proposed to define the dose constraint as a constraint set as a prospective upper bound of individual dose used to define the range of options considered in the process of optimisation related to a given radiation source, clearly highlighting its prospective character.

The revised Euratom BSS currently proposes three types of dose constraints as dose related tools for optimisation: for occupational exposure, for public exposure and for medical exposure. In the draft Euratom BSS, version 24 February 2010[4], which was recommended by the Article 31 Group of Experts, the respective requirement on dose constraints for occupational exposure reads as follows:

"In the optimisation of protection in planned exposure situations related to a given radiation source, dose constraints shall be established, as appropriate, for workers and members of the public.
(a) For occupational exposures, the dose constraint shall be an upper bound on the individual dose to define the range of protection options considered in the process of optimisation, to be established as an operational tool by the undertaking under general supervision of the competent authorities. In case of outside workers the dose constraint shall be established in cooperation between the employer and the undertaking."

This draft requirement clearly assigns the responsibility of establishing occupational dose constraints to the operator (undertaking), under the general supervision of the regulatory authority; in case of outside workers, the responsibility is shared by the employer of the outside worker and the operator of the source.

With regards to time periods for which the dose constraints shall be established the draft Directive proposes that In general, dose constraints shall be established in terms of individual effective dose over a year or any other appropriate shorter time period.

Further to the requirements in the draft Directive, the European Commission may provide, at a later stage, guidance on the practical use of dose constraints.

3. Council Directive 96/29/ Euratom of 13 May 1996, laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (Official Journal L-159 of 29.06.1996, page 1).

4. http://ec.europa.eu/energy/nuclear/radiation_protection/doc/art31/2010_02_24_draft_euratom_basic_safety_standards_directive.pdf.

VI. DOSE CONSTRAINTS IN NUCLEAR POWER PLANTS – OPERATORS' PRACTICES AND EXPERIENCES

Dose constraints or dose-constraint-like-instruments were used for radiation protection purposes in operation of NPPs even before this concept was elaborated in the ICRP Publ. 101 or ICRP Publ. 103. These instruments were not necessarily explicitly related or linked to optimisation, and in most cases, they were not understood as values below which the optimisation should continue (ICRP Publ. 103, Paragraph 256). While optimisation is required in most cases, its relation to dose constraints, where they exist, is not unified; and the optimisation is not necessarily linked to their use. Some of these instruments and approaches address routine and/or day-to-day operations and while prospective in nature, may not be using constraints as they are meant in ICRP Publ. 103.

Table 1 lists examples of use of dose constraints, dose-constraint-like-instruments, or other occupational exposure management criteria in existing practices in several utilities, i.e. before implementation of the ICRP Publ. 103. It can be seen that there are different terms used in place of dose constraint – exposure control level, administrative dose limit, planning value, admin limit, station administrative limits, etc.

Table 1. Dose limits, dose constraints and other instruments used in internal (utility) control of individual doses

Country	**Operator**	**Individual dose constraints or dose-constraint-like-instruments**
Canada	Ontario Power Generation	2 levels of individual dose constraints or dose-constraint-like-instruments: - Exposure Control Level (ECL) - Administrative Dose Limit (ADL) Annual exposure control levels for nuclear energy workers: - Whole body including tritium committed dose: 1 rem (10 mSv) - Tritium committed dose: 0.150 rem (1.50 mSv) - Skin: 10 rem (100 mSv) - Hands and feet: 25 rem (250 mSv)
France	EDF	Less than 55 workers[5] with a dose higher than 14 mSv on a twelve-month rolling period. Less than 420 workers[5] with a dose higher than 10 mSv on a twelve-month rolling period. (apply for all workers i.e. about 42.000 rad workers – sub contractors can apply their own values but with a dose constraint not higher than 16 mSv on a twelve-month rolling period)
Japan	Tokyo Electric Power Company	The regulatory dose limits: 100mSv/5years and 50 mSv/year, 5mSv/3months(women)

5. These goals are revised every year in order to achieve a decreasing trend of about 5 to 10% per year.

	NPPs: Fukushima Daiichi NPP Fukushima Daini NPP Kashiwazaki-Kariwa NPP	[Dose limit control] The screening levels are voluntarily set by nuclear operators to assure that doses of workers do not exceed the regulatory dose limits. When the screening levels are exceeded, more detailed control is implemented to achieve severer optimisation. The screening level : 80mSv/5year and 18mSv/year, 4mSv/3months(women) [Routine dose control] Radiation Work Admissions (RWAs) are drawn up for each work and works are controlled by RWAs. Along with day-by-day dose reduction effort based upon ALARA concept, individual dose is controlled to be kept as low as possible.
Slovenia	Krško NPP	Station administrative limit for individual whole body dose due to external radiation is 10 mSv/y for category A workers and 6 mSv/y for category B workers. Authorisation is required to exceed these limits. In accordance with the regulation, the plant has proposed to the authority external and internal dose constraints. These values are used as authorised dose constraints: - The dose constraint due to external radiation is 15 mSv/y for category A workers and 6 mSv/y for category B workers. - The dose constraint due to internal exposure is 0.2 mSv/y. If these dose constraints are exceeded the Slovenian Radiation Protection Authority must be informed and corrective actions taken by the plant. Regulatory dose limit is 20 mSv/y. A process exists in the regulation for a planned special exposure to exceed 20 mSv/y.
Spain	Cofrentes NPP	- Investigation: 10 mSv/y (not applicable in refuelling outages) - Intervention: 18 mSv/y or 90 mSv/5 years
Sweden	Forsmark NPP	- Planned annual dose shall not exceed 10 mSv - No actual individual annual dose shall exceed 15 mSv - Not more than 1% of the actual individual annual doses shall exceed 10 mSv - No internal contamination exceeding 0.3 mSv
	Oskarshamn NPP	- Dose/day: Planning value = 3 mSv; Check point = 2.5 mSv - Dose/month: Planning value = 10 mSv; Check point = 8 mSv - Dose/y: Planning value = 20 mSv; Check point = 18 mSv

		- In addition, dose rate constraint < 4mSv/h, that is used as a complement
	Ringhals NPP	- Authority limits: 50 mSv/y (calendar) and 100 mSv/5 years (rolling) - In Ringhals: 10 mSv/y - Some contractors: 20 mSv/y
Switzerland	Leibstadt NPP	- Administrative dose constraint or dose-constraint-like-instrument: 10 mSv/y for plant staff. - For contractors, dose constraint or dose-constraint-like-instrument determined by the contractor's employer (cannot override 20 mSv/y).
UK	Sizewell B NPP	- The utility (British Energy) has adopted a Company Dose Restriction Level (CDRL) of 10 mSv/y - The national dose limit in UK is 20 mSv/y.
USA	Exelon Nuclear	- Guideline: 2 rem/y (20 mSv/y) - Work group supervisor and radiation protection manager approval: 2-3 rem/y (20-30 mSv/y) - Site vice-president approval: 3-4 rem/y (30-40 mSv/y) - Executive vice-president approval 4-5 rem/y,(40-50 mSv/y) - Legal limit: 5 rem/y (50 mSv/y)
	PPL Susquehanna	- Regulatory limit remains at 5 rem/y (50 mSv/y). - The regulatory authority is considering adoption of a limit of 2 rem/y (20 mSv/y) or 100 mSv/5 years. Station administrative guideline: - Personnel dose limit: 2 rem/y (20 mSv/y) - Authorisation required for an individual to exceed 2 rem/y (20 mSv/y) annual exposure. - Additional authorisation required for an individual to exceed 3 rem/y (30 mSv/y) annual exposure. - While an authorisation process exists to grant an extension to exceed 4 rem/y (40 mSv/y), station management has stated that it would be very unlikely to grant such a request, absent a very compelling argument for such an extension. - While a process exists in the regulations for a planned special exposure to exceed 5 rem/y (50 mSv/y), PPL does not expect to use that process and has procedurally stated that the process would not be used.

The usage and meaning of these instruments are, in some of these cases, consistent with that of the ICRP, i.e. from a prospective view *to serve as an upper bound and as a tool for optimisation*. However in other cases, these instruments are understood as utility dose "limits", which are set below those being enforced by regulator, however they are actually internal administrative limits selected in part to ensure that the regulator's limit is not exceeded.

In latter cases, these most probably do not serve *per se* as tools for optimisation, and they may apply to routine and/or day-to-day operations and not primarily to new and/or substantially modified facilities. That is, they are used for internal (utility) control of exposures. Several utilities also adopted an approach to apply corrective measures; if a certain level of internal administrative limit is reached (e.g., reaching of 80% of an internal administrative limit may trigger an alarm, *etc.*). While this kind of approach is not fully consistent with the ICRP meaning of dose constraint, since, for example, it doesn't itself explicitly oblige an operator to perform optimisation below the selected value, it will secure compliance with the regulator's limit.

In Japan, the use of dose constraints or dose-constraint-like-instruments in existing practices in several utilities was well established and required practice even before implementation of the ICRP Publ. 103. As can be seen from the Table 1, there are different terms used in place of dose constraint – exposure control level, administrative dose limit, planning value, admin limit, station administrative limits, *etc*.

As described in Section VII, in the United States, regulations require the development and implementation of an ALARA programme at facilities. In implementing that programme at more complex facilities such as NPPs, such a programme often includes operational elements such as task-specific radiation work permits, monitoring of work by supervisory and radiation protection staffs, the use of alarming dosimetry with set points selected to control work and to detect unexpected radiation fields, the use of training for specific tasks and so on. Such programme elements are used in addition to the administrative dose guidelines described above as a means of implementing a programme to ensure exposures are maintained at levels which are ALARA.

VII. IMPLEMENTATION OF THE ICRP RECOMMENDATIONS ON DOSE CONSTRAINTS INTO REGULATIONS – ISSUES TO BE CONSIDERED

(1) Constraint *versus* limit – only a linguistic problem?

The fact that dose constraint may be misinterpreted as a rigorous limit is recognised by the ICRP, In ICRP Publ. 103, paragraph 42, it is said: "*The Commission recognises, however, that the word 'constraint' is interpreted in many languages as a rigorous limit*". *However in paragraph 233 the ICRP explicitly states: "The Commission wishes to emphasise that dose constraints are not to be used or understood as prescriptive regulatory limits."*

None-the-less, this situation may fuel further interpretations, and allows a wide range of applications. To address this, it is recommended to refer to the broad meaning of dose constraints as is described in ICRP Publ. 103, paragraph 256 (see Section III).

As seen in paragraph 256, the interpretation of the term dose constraint ranges from a high level of significance expressed as "general and principal tool for optimisation" to a "lower level tool" used in work planning in some specific situations.

Different interpretations can be caused not only by linguistic understandings of the term itself, but also by different perceptions of the term's meaning. These differences could lead to significant consequences in practical implementation of occupational radiation protection (degree of regulatory involvement, total risk management, *etc*.).

The following examples have been developed to describe common radiological protection practice using optimisation and dose criteria. The facility owner(s)/operator(s) and the applicable regulator(s) may wish to consider these examples, that are appropriate to the countries or regions in which the source(s) is to be constructed and operated, when deciding how to implement dose constraints.

Review of the materials provided by various countries suggests that varying definitions of, and purposes for, dose constraint have been used in the setting of occupational radiation safety. In other cases, a "dose constraint" is set which marks the end point of an optimisation process and in some cases the "dose constraint" is used not only prospectively but also retrospectively as a regulatory instrument. It may be questioned if those concepts are fully consistent with the recommendations of ICRP Publ. 103 related to the intended definition of dose constraint. It is of course true that various countries use a term called dose constraint (or a similar term) that was promulgated before the release of ICRP Publ. 103; in that light, such applications are being compared to the most recent revision in language describing the ICRP's view of the concept of a dose constraint. A change in some countries' uses of the concept of a dose constraint may be expected because of the release of Publication 103. For some countries, sources, and circumstances, the changes found to be appropriate may not be large and may include conceptual and/or terminology changes.

Examples:

A pair of examples may be helpful in elucidating changes in approach which might be considered.

Example number 1: shielding (of a room within which a source emitting radiation may be found) is to be constructed to reduce doses to workers (usually located outside of the room) and to members of the public who may spend limited amounts of time near but outside of the room. Most workers at such facilities receive dose primarily from one source or at least a small number of sources. Taking into account substantial experience at similar facilities in operation, the designer and operator of the proposed facility are able to define a shielding configuration which may be constructed at an acceptable price and which should result in doses well below the occupational dose limits and in line with a dose criteria for facilities of this type. The proposed operator, often in discussion with the regulator, may or may not define practicable means to further slightly reduce worker doses at this type of facility. Establishment of a generic dose target, even in retrospective fashion, by the regulator in this case may be considered to be at or near the end point of a dose optimisation process.

As this example demonstrates a typical type of protective approach that is used in designing new facilities, and that attempts to use all available experience in optimising protection. As a result, future worker doses would be expected to be near the dose target established for the design. This is a common type of approach, and represents good optimisation in practice, but seems to be conceptually different than the use of an ICRP 103 dose constraint. Reasonable design efforts are anticipated to result in individual doses very substantially below dose limits, because only one predominant source is likely to affect individual doses at the facility, and because further dose reduction is likely to be very small or impracticable (economic and social considerations taken into account).

Example number 2: a regulator establishes an individual dose value that is to be met both during prospective evaluation of anticipated facility operations and also during retrospective evaluation of actual facility operations. Penalties may be imposed by the regulator if actual operations result in individual doses exceeding the selected numerical value. In this context, the numerical value may be perceived as a second (and lower) dose limit, since regulatory penalties may be imposed, potentially even if the circumstances leading to the value being exceeded may have been somewhat extraordinary, outside the bounds of the prospective evaluation, and/or reasonably examined via the facility's day-to-day dose optimisation programme and found to be justified. As stated elsewhere in this document, the concept of dose constraint as described in ICRP Publication 103 neither endorses the use of dose constraint as a dose limit nor its use in retrospective evaluation of day-to-day operations. In this situation, the concept that appears to be used is more of an action level, requiring investigation of reasons for incurring an actual dose exceeding the action level, and requiring the definition of appropriate corrective actions to reduce the probability of future exceedance of the action level would be preferable.

In such case, the exceeding itself would not result in regulatory penalty, unless the licensee's non-conformance to its own procedures occurred and was subject to regulatory authority oversight.

Here again, this common approach of using action levels as criteria to instigate operator (or even perhaps regulatory) actions is a widely used tool for radiological protection. This concept, however, does not seem to be similar to that proposed by the ICRP in Publication 103.

(2) Dose constraints in prospective evaluations and as one means of initiating investigations of actual operations

The concept of dose constraint was described by ICRP primarily in terms of its use in prospective evaluation of facilities to be built and/or sources to be used and may be extended for use when prospective evaluation for substantial modification of existing facilities/sources is being planned. The concept apparently was not intended as a means of prospectively evaluating routine operational or maintenance task on a day-to-day basis. Dose optimisation processes continue to be needed and used in daily work

planning; however, the concept of a dose constraint does not seem to be appropriate in that timeframe of work planning relatively immediately prior to job execution.

As an example, a reasonable approach for NPPs would include the prospective evaluation of tasks expected to be performed at the plant during routine operations and anticipated operational occurrences. Dose estimates for such future tasks may often be based on exposures accrued on similar tasks at operational plants at which good industry design and work practices are being used. When those prospective evaluations suggest that for some workers, individual dose limits may be approached, then a form of dose criteria, target or action level for the workers (presumably within a relatively small number of craft or work groups) involved in those tasks is reasonable. Further work on the facility design and initial operational planning may then include additional focus on that set of workers for that set of tasks expected to contribute substantially to anticipated exposures approaching the individual dose limits and/or the dose criteria established for that set of circumstances. When the design of the facility or substantial modification has been finalised, the dose criterion that was established has served its purpose and is not directly applicable during the actual day-to-day operation of the facility. However, it is useful to check operational doses against the dose criteria to check that the design intent has been properly implemented and action taken if necessary to adjust the level of protection.

Investigation of actual doses exceeding the dose criteria for a specific set of tasks is an outcome of normal evaluations of plant operations using the plant's programme to maintain doses as low as reasonably achievable. Results may of course be informative to future prospective evaluations of doses for workers at new facilities.

(3) Risk of dose constraints being interpreted as an "additional" limit or as a new "standard of care" for workers

The annual dose limit for an individual is related to all sources contributing to the exposure of an individual. A dose constraint, if established, is strictly directed to only one source and the contribution of that source to the total dose received by the individual from all relevant sources. As such, a dose constraint should not be interpreted as a dose limit.

Further, a dose constraint is applicable primarily toward prospective evaluation of facilities to be built and/or very substantially modified. In performing those prospective evaluations, both anticipated routine operations and operational occurrences should be considered. Job tasks that are not reasonably anticipated to be performed should not be a basis for the prospective evaluations. If during facility operations, performance of a job task outside of the scope of the prospective evaluation is found to be needed, the facility's ALARA (day-to-day exposure optimisation) programme should be used to optimise protection for that job task. However, the need to perform that task and accrue the resultant dose does not imply that the prospective evaluation was flawed or that the architect-engineer or constructor or owner or operator of the facility failed in its duty to reasonably plan for worker protection. Only if it is clearly shown that a company was negligent in performing the prospective evaluation, or constructed or operated the facility contrary to its results, would a legal question about liability appear to be open to investigation.

In this arena, the role of the regulator is especially meaningful. In describing the purpose of any dose constraint required by regulation to be developed by a facility operator, the regulator should practicably explain that the operator will be performing an evaluation (and outlining limitations of such evaluation) of operational experience and perceived good practices in establishing the value of the dose constraint. The regulator should also state if any investigative approach is to be used by the operator if a dose constraint defined by prospective evaluation is exceeded during actual facility operations.

Dose constraint could be misinterpreted as a dose limit or a limit on actual operational doses if a regulatory violation were (actually or threatened) to be cited for exceeding a dose constraint defined for prospective evaluation. The same is true if source-specific circumstances could not result in reasonably explained prospective or retrospective exceeding of a constraint generically established for a set of sources. Such reasonable explanation could, for example, include consideration of the (potentially unique) work/tasks to be performed, the numbers of workers reasonably able to be trained and qualified to perform those tasks, and/or non-radiological risks to workers to undertake the tasks. Potentially also, considerations could include whether the tasks could reasonably be undertaken, could reasonably be deferred, or could reasonably be accomplished all or in critical part by substituting other tasks for those initially planned.

Exceeding a prospectively defined dose constraint should not be a regulatory violation but could reasonably be required to trigger a practicable licensee evaluation of work retrospectively, to substantially reduce the possibility of future situations leading to exceeding of the dose constraint. Such an evaluation might include investigation of the situation that occurred and the adoption of appropriate corrective actions for future planning of similar work. A regulatory authority may review the corrective actions taken (for example, forming an opinion as to the timeliness and adequacy of corrective actions taken to reduce the possibility of future exceeding of the dose constraint).

Note should be made that if a facility designer, owner, or operator defines a dose constraint to be prospectively applied to a source, a similar thoughtful description of the purpose for the constraint, the basis for its numerical value, and investigative plans should the dose constraint be retrospectively exceeded should be available to the designer, constructor, owner, operator, and regulator as facility design progresses.

(4) Dose constraints as only one of many factors in total risk management

The ICRP recommendations may by some readers be interpreted as being written as potentially too narrowly focused only on one factor – individual dose limit, with the wording of the recommendations being interpreted by some readers as containing insufficient explanation of context for the many NPP operators and radiation protection organisations, that embrace a “holistic” approach to controlling the total set of risks to be managed in operating and maintaining a nuclear power or similar facility.

Although ICRP Publication 101, in Section 3.2, clearly explains that the attributes of the best protection option must be broadly and holistically assessed, some of the wording of the ICRP recommendations may be interpreted by some to place the radiation protection of an individual in the work place as the only risk considered in establishing a constraint. That singular focus as perceived in the wording of the ICRP, could perhaps be changed 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). NPPs have provisions in place that optimise management of risk, including radiation protection/occupational dose. Occupational dose to an individual worker may for example appropriately need to be higher in some situations to achieve a lower collective occupational dose or a lower dose to members of the public. However, exceeding a dose constraint should not generally be authorised solely based on an objective to obtain a lower collective dose.

In general, management and optimisation of individual and collective doses includes but is not limited to:

- use of a dose constraint or dose constraint like instrument for the optimisation of individual dose;
- study of individual and collective dose distributions as used in the process of optimisation;
- collection and analysis of national experience;

- examples of good practice;
- rolling averages or rolling limits for defined time intervals[6].

However, occupational radiation protection is not practiced in a vacuum with exposure to ionising radiation as the overriding risk, and optimisation cannot be limited to dose control. Industrial safety, nuclear safety, environmental safety and facility reliability in production of electricity may at times have equal or higher weighting in determining optimised risk controls. As another type of example, high quality workmanship may be accomplished by giving one worker a higher dose than one or more less experienced workers as plans are developed and implemented to ensure additional workers can perform work of equal quality.

Total risk management is practiced at NPPs now and needs to be understood as the ICRP recommendations are implemented at NPPs globally. At NPPs, the occupational radiation protection programmes also have day-to-day dose optimisation processes in place. Before workers are assigned to specific jobs, their job hazards are assessed. There is an assignment of electronic dosimeters with pre-set dose rate and accumulated dose levels. The worker may be equipped with remote audio communication capability and be monitored by qualified health physics technicians by closed-circuit cameras and/or by craft supervision. Additional administrative or hardware devices can be provided to the worker commensurate with the risk.

(5) Dose constraints in the process of optimisation

According to the ICRP Publ. 103, Paragraph 198 "Constraints and reference levels can thus be described as key parts in the optimisation process that will ensure appropriate levels of protection under the prevailing circumstances". The ICRP further says: "Treating a dose constraint as a target value is not sufficient, and optimisation of protection will be necessary to establish an acceptable level of dose below the constraint." (ICRP 2007, Paragraph 230).

In introducing dose constraints into regulatory framework, there is a need for further information/guidance, for example:

- How are individual dose distributions over time used in the optimisation process: evolution; type of industry; how are "outliers" addressed; as an indicator for assessing optimisation results?
- What constitutes an "inequity" in individual dose and how are such circumstances addressed? Can inequities be addressed by means other than dose reduction for workers with higher dose (e.g., annual compensation) as part of the evaluation of social and economic factors?
- How are "sample groups" identified and/or defined?

As a means of identifying types of guidance (and the higher level technical content of such guidance) that may be helpful to regulators, facility owners/operators, and architect-engineering and construction firms designing source-containing facilities, the following three possible situations have been developed:

6. Germany abandoned rolling 3-month dose limits in its last radiation protection and x-ray ordinances because of disproportionately high administrative burden for too little benefit.

Situation 1:

To which categories of workers should dose constraints apply?

I. Nuclear Power Plants

As described in the ICRP Publ. 103, dose constraints are to be used to ensure a basic level of protection for the most highly exposed individuals from a source. Logically, there may be two (perhaps three) categories of workers at a NPP for which the setting of dose constraints may be particularly appropriate:

- those workers whose prospectively estimated doses from a single source (likely a single reactor or the set of reactors on a single site, depending on how the "source" is defined) may approach the dose limit; or
- those workers whose prospectively estimated doses from multiple sources may approach the dose limit; and perhaps
- those workers whose prospectively estimated doses from one or more sources are substantially higher than those of their colleagues, such that their estimated doses are arguably inequitable compared to those of their colleagues and their doses are prospectively estimated to be a very appreciable percentage of the dose limit.

These categories of workers may be examined separately. Workers for whom prospective doses from a single source may approach the dose limit should be the subject of special attention during the design and initial operational planning phases of NPP design and construction. For such cases, the use of an individual dose constraint applicable to prospective doses due to routine operations and anticipated operational occurrences may be applicable. The value of such a constraint should be set by the architect-engineering organisation in consultation with the facility's owner and proposed operator and informed by conversation with the regulator and good prospective exposure-control practices available from similar facilities. While the dose constraint may be source-specific, several principles apply to setting a specific numerical value:

- The dose constraint should be set below the dose limit and below any revised dose limit that a reasonable assessment of current regulatory practice and philosophies suggest is very likely to be adopted within the next few years.
- The dose constraint should be set at a value not to exceed current industry exposures for a similar group of more highly exposed workers at a site in that country or region of the world, absent clear and documented justification.
- The dose constraint should be set considering an assessment of the consequences of using emergent, but reasonably proven and reasonably cost-effective technology in facility design and construction. An example may be a relatively new type of shielding material or source-reducing water chemistry.
- The dose constraint should be set after the radiological engineering staff's assessment.
- The dose constraint should not be set assuming larger numbers of individuals accruing the same or higher collective exposure as for a smaller number of individuals performing the same set of tasks, absent an evaluation that shows such a revised dose distribution is appropriate. Note that as workers with specialised skills are trained and qualified, there may be increased collective and individual doses until the skill levels increase across the larger number of individuals.

- The dose constraint should be set recognising that NPP workers may be exposed to a number of risk agents. Overall risk to the worker(s) should be minimised to the extent reasonably achievable. Reducing one occupational risk (radiological) while increasing other risks (e.g., industrial safety risk) may not be appropriate absent an evaluation of an overall reduction of risk.
- Similar to the item above, the dose constraint should be set recognising that there may be occasions when occupational radiological risk may only be reduced with an increase in radiological risk to members of the public. Evaluations should be performed to determine which of those risks may be more important to control.

In the case of workers whose doses may result from exposures from multiple sources, there may be two sub-categories: first, workers of a company operating multiple reactors and/or reactor sites (depending on how the "source" is defined), and second, workers of a contractor who may visit source facilities operated by one or more utility operating companies (often, workers with highly specialised skills in substantial demand). In either case, special attention should be given during the design and initial operational planning phases of NPP design and construction. For such cases, the use of an individual dose constraint applicable to prospective doses during routine operations and anticipated operational occurrences at the sources under design may be applicable and should be informed by doses being received at sources in operation.

The value of such a dose constraint may be established differently depending on whether (or not) the worker is an operating company employee or a contracted worker. For the operating company employee, the value of the dose constraint should be set by the owner and proposed operator of the source facilities. The value should be established in consultation with the architect-engineer for the source(s) in design, the regulator(s) for that source(s) in design, and assessment of good prospective exposure-control practices available from similar facilities. The owner/operator needs to determine how to manage worker exposure at multiple facilities within individual dose limits. For the contracted worker, the process may be similar to that described above if the contracted workers are employed virtually all of the time at plants operated by one company. For contracted workers moving from plant to plant across operating companies, the process may evolve in a different way. The contractor company wants to ensure its employees continue to work productively all year, and the operating companies need continued access to the skilled workers of the contractor company. Thus, the contractor company may express its views regarding plants under design as to dose constraints which may be appropriate to enable its workers to access the plants and perform the requested job tasks.

While the architect-engineering firm may establish a dose constraint in consultation with a plant's owner/operator and regulator, the input from the contractor companies should also be given consideration, to ensure continuing plant safety, efficiency, and reliability. Principles for establishing a dose constraint for these categories of workers are the same as those described for a worker receiving exposure primarily at one site.

For those workers receiving arguably inequitably larger doses than their colleagues in a work (craft) group, exposure control management tends to be a question of the dose optimisation process used by the plant on a day-to-day basis for the craft group (e.g., mechanics). Prospective management during design and initial operational planning is unlikely to be effective, absent the actions taken to address the more highly exposed workers overall (as described above). The likelihood of a design's resulting in inequitable dose distributions among a group of colleagues should be assessed by the architect-engineer in consultation with the owner/operator. If substantial inequities are assessed to be likely, then consideration should be given to the use of a dose constraint established to address that anticipated issue.

II. Non-nuclear energy and Other Facilities

Beyond the three categories of workers at a NPP for which the setting of dose constraints may be appropriate, there is the potential for another group of occupationally exposed workers to be considered, for which the results of prospective evaluations may be subject to restriction below a dose target set below the individual dose limit. This concept is employed, for example, in some countries for facilities such as medical diagnostic or treatment facilities, where a value on the order of 1 mSv/y is used as an upper-bound dose target for some categories of occupationally exposed workers. The concept is also employed in some countries as an administratively established dose target for occupationally exposed workers at NPPs who do not routinely enter the radiologically controlled areas but rather work almost exclusively in office areas on the plant site outside of the radiologically controlled area.

Situation 2:

Will enforcing dose constraints result in negative consequences?; and if yes, how are these consequences treated by the operator and regulator?

How are dose constraints for occupational radiation protection balanced with the management of other risks?

Both the organisation(s) performing the prospective evaluation for a facility and the regulator reviewing that evaluation have the responsibility to ensure the prospective evaluation is done with high quality and any related dose constraint is established following a consideration of the relevant source-specific circumstances. The recommendations of the ICRP are focused on radiological safety, and the concept of the occupational dose constraint in particular is focused on radiological safety of the workers. The prospective evaluation for a facility and the numerical value of an occupational dose constraint applicable to that facility are to be developed with a focus on experience to that date in managing workers exposed to radiation at other facilities with similarities to those of the planned facility. That experience would be expected to include assessment of industry design and operations which have resulted in relatively good exposure management practices.

There are at least three considerations worthy of mention here, derived from the principles described in Section VIII(5) of this document, for setting the numerical value of a dose constraint.

The first consideration when performing prospective evaluations or setting dose constraints, is that extreme caution should be taken when taking account of the use of either (a) emergent technologies which have not been proven both effective and reasonably cost-efficient for the specific type of facility being designed or (b) personnel training or management practices which have not been proven to be effective in a variety of circumstances or reasonably cost-efficient in the anticipated circumstances.

The second consideration is to assess worker risk not just from the perspective of radiological safety but also the perspective of industrial safety risk and management of the environmental risk of the facility as it may be affected by the boundaries placed on radiological risk to the workers. Overall risk to the workers and from the facility should be minimised to the extent reasonably achievable.

The third consideration is to assess whether the prospective evaluation and/or proposed dose constraint meets the intent of the ICRP as described in Publication 103. The dose constraint is to serve as an upper bound on dose in optimisation of protection for the source. To meet that objective the prospective evaluation and/or proposed dose constraint must address the totality of the planned routine operation and anticipated operational occurrences for the lifetime of the facility. Incomplete analysis may result in a worker retrospectively exceeding the dose constraint and/or the facility incurring increased collective dose or other costs (which may not be reasonable) to ensure compliance with the dose constraint. The architect-

engineer, the owner, the operator, and the regulator should act to ensure that prospective evaluations and established dose constraints are based on information deemed reasonably complete; and also to ensure that the regulatory authority's and/or operator's investigative schemes (when a dose constraint is approached or exceeded) consider whether the circumstances are within or beyond the boundaries of the evaluation and/or *constraint*, as potential future or other corrective actions are defined.

It is important to note that different organisations may have different motivations to ensure that prospective evaluations to demonstrate individual and collective doses are maintained at levels which are as low as reasonably achievable. Common to all is the desire to ensure workers are protected, such that no workers are anticipated to be exposed to unacceptable risk. Beyond that common motivation, several emphases may emerge as relates to NPPs:

- Supplier of nuclear steam supply systems (NSSS) – motivation to reduce doses during anticipated operational and maintenance periods to enhance marketing of their design in competitive bidding processes for additional facilities. This may be tied directly to initiatives in enhancing equipment reliability and maintainability within the context of maintaining a high level of nuclear safety.
- Supplier of balance-of-plant design – similar motivation as described for NSSS supplier. This may also be tied to initiatives in enhancing plant constructability and ensuring a seamless interface with the NSSS equipment.
- Facility owner and operator – motivation to reduce prospective dose as a component of enhancing safe and efficient plant operation and in ensuring good relationships with the relevant regulator(s), the local populace, the plant workers, and other stakeholders during plant design, licensing, and construction and into plant operations.
- Regulator – motivation to reduce dose within the context of providing independent oversight of facility design and construction and conducting facility licensing, including a role in communicating relevant social considerations that may bear directly on dose optimisation during those phases of facility preparation.

Situation 3:

<u>Is additional guidance needed for workers moving from one reactor site to another during a year?</u>

As described to a limited degree in Situation 1, one category of workers at nuclear power facilities is the set of specialised workers whose doses may result from exposures from multiple sources (depending on how "source" is defined for them). These workers tend to be relatively few in number (on the order of a few thousands worldwide) but with highly developed skills in demand at multiple power stations within and across national boundaries. As noted in Situation 1, the contractor overseeing the assignment of these workers has a relatively more important role in helping inform the optimisation process used for these workers.

In the setting of dose constraints or goals for such workers, the designers and operators (and the regulators reviewing that process) should consider factors supplemental to those used for most other workers. Examples are as follows:

- How is source to be defined for these workers (or subsets of those workers), which may differ from the singular source primarily discussed in ICRP Publ. 103 and in national regulatory guidance, and
- With what set(s) of workers is the dose distribution to be defined and the equity of distribution(s) reviewed, and

- How may the social and economic factors pertinent to those workers differ from those for other workers?

Clearly, the workers' doses need to be maintained below the applicable dose limits and a robust optimisation process needs to be applied to the workers' planned tasks. The questions stated above should be considered in establishing a dose constraint or equivalent target as part of the optimisation process.

(6) Need for education and training specifically addressing dose constraints?

Highly-skilled workers are a limited population whose individuals are difficult to replace. The process of training new, highly skilled workers can often result in their receiving high exposures during their apprenticeship (e.g. highly qualified contract and utility workers). There are several aspects to be considered with respect to this issue that could impact on the selection and use of dose constraints:

- Issues associated with disparity of worker education and training (in radiation safety, occupational radiation protection, the technical aspects of the task being planned, *etc*.) – identify also other means/approaches to managing exposure disparities not necessarily using dose constraints.
- Enhancing programmes in education and training may result in less disparity in dose distributions (as well as reducing collective doses) – this is related directly to the job type and the experience of a worker in that type of job.
- What are the existing approaches (e.g., mentoring programmes, mock-up facilities) to ensure appropriate worker training?

VIII. ANALYSIS AND CONCLUSIONS

The concept of dose constraints, established by the ICRP and implemented in BSS-1996 edition, EU-Directive, as well as in the documents in revision is intended to be used primarily in optimisation of protection from a particular source as a source-related restriction on the individual dose from a source in a planned exposure situation. By using dose constraints in optimisation of protection it is expected that equity of distribution of exposure among the group of concerned individuals will be satisfied. However, in implementations of dose constraints into regulatory frameworks, as well in their practical use, there are observed unequal and non-harmonised approaches, that may rise from misunderstanding of the concept of optimisation using dose constraints.

The actual implementation of dose constraints in planned exposure situations, particularly by operators in the nuclear industry, depends, in most cases, on individual approaches and on co-operation between registrant and licensee and the regulator. While the concept of dose constraints or dose constraints-like instruments, or at least the concept of dose constraints, is used in activities and facilities or is implemented in the regulatory framework in some countries, there are no dose constraint values required to be set *a priori* by national regulations.

Furthermore, dose constraints for the public and for workers are generally not interpreted or implemented as being identical regulatory instruments. In public exposure, dose constraints are set or approved by the authority and in occupational exposure by the registrant or licensee. In radiation protection of the public from the planned operation of the source or from a planned activity, all members of the public could be protected by using a dose constraint. However in protection of workers it may depend on decisions of the licensee on whether or not to use to use a formalised dose constraint. In such situation, in some cases protection of employees may be based on optimisation using dose constraints – intended to help ensure equity of dose distribution, while in other cases optimisation without a formalised dose constraint will be used, which may, in some cases, increase the probability of an inequitable distribution of doses among employees.

Another potential difference between the ICRP intention as expressed in ICRP Publ. 103 and existing uses, may be seen in the fact that most operators use dose constraints, or a similar concept, as a benchmark value that enables (retrospective) evaluation (and adoption of appropriate revised radiation protection measures) when doses from their operations exceed the planned expectations, i.e. when occupationally exposed workers actually receive doses that exceed a planning value established for a specific task or set of tasks that were to be accomplished. These values are called for example operational or administrative limits or goals. If the term dose constraint is used for such retrospective analyses of planned operations (especially for day-to-day tasks as compared to anticipated annual operational plans), this may be seen as inconsistent with the ICRP understanding of dose constraints, which are according to ICRP Publ. 103 not intended to be used as a form of retrospective dose limit. From these descriptions, there is a clear intention for dose constraints to be a prospective value, to be used for the purpose of prospective optimisation of doses from a particular source.

The question that remains after this, even simplified analysis of existing approaches and practices, is whether the dose constraint, not as the term, but as the idea and the principle, is or will be adopted into the regulatory practices in planned operations of activities or facilities that may cause people to be exposed to radiation. In many cases, even if the dose constraint (or equivalent instrument) is used, it is primarily used at the design stage, or during major modifications of the installation.

While there is a clear resistance from operators of nuclear facilities to have an additional and enforceable (by national regulator) "limit" (i.e., misinterpretation of dose constraint). There is also a clear and widely accepted need for optimisation processes that are seen as necessary steps not only to keep doses below dose limits but also to ensure that inequities in dose distribution are minimised. The concept of "penalising" operators of nuclear facilities for exceeding dose constraints should not be emphasised, and at the least any such sanctions should remain less significant than sanctions related to exceeding a regulatory limits. In such cases, the reasons for which the actual dose exceeded the prospectively estimated dose should be taken into account. Here, the role of the regulatory authority will be different depending on whether it is a public dose constraint, where the role of regulator is significant, or it is a worker dose constraint, where the operator is responsible for the definition of the dose constraint.

Dose constraints are seen to be accepted in general as one tool in the optimisation process to reduce the inequity in the distribution of individual doses. It is also recognised that in the field of occupational exposures, there are other tools used for the same purpose, like individual dose targets for a specific facility or a specific job, or, more broadly, by engaging specific actions to first identify those most exposed workers, their usual tasks and engaging processes to identify protection actions to reduce their exposures. Most employers and licensees are in fact applying the optimisation principle looking at the same time for both a reduction of collective exposures and a reduction of the number of workers exposed to the highest individual dose levels. It is thus necessary to leave flexibility to registrants and licensees and persons or organisations responsible for activities and facilities to use various optimisation tools depending on type of operation.

In order to ensure the appropriate and correct implementation and use of dose constraints, the revised international regulatory documents reflecting the current status of knowledge, specialised publications of the ICRP and of other professional or specialised organisations, providing comprehensive explanations and guidance, are irreplaceable and needed.

Appendix 1: ERPAN Survey on Dose Constraints in the Non-nuclear Energy Sector

1. Does your country use dose constraints in the context of occupational exposures (non-nuclear sector)?

Belgium	No
France	Yes
Greece:	Yes
Ireland	Yes
Luxembourg	No
Norway	No
Slovenia	Yes
Spain	Yes
Sweden	Yes
Switzerland	Yes
United Kingdom	Yes

2. If so what are they called?

Belgium	Dose constraint/Dosisbeperking (Dutch)/Contrainte de dose (French)
France	Dose objectives
Greece	Dose constraints
Ireland	Dose constraints
Luxembourg	Dose constraints
Norway	No special name is used.
Slovenia	Dose constraint (dozna ograda)
Spain	Dose constraints or Reference values
Sweden	Dose constraint (Dosrestriktion)
Switzerland	Notification threshold for occupationally exposed persons (not called dose constraints).
United Kingdom	Dose constraints

3. Are occupational dose constraints mentioned in national legislation/regulations?

Belgium	Yes
France	Yes
Greece	Yes
Ireland	Yes
Luxembourg	Yes
Norway	Not explicitly
Slovenia	Yes
Spain	Yes
Sweden	Yes – the regulations issued by the Regulatory Authority are part of the legal framework.
Switzerland	No directions are mentioned for the worker but for dosimetry services, Radiation Protection Ordinance (Art. 49).
United Kingdom	Yes

4. If so, please provide a reference to the relevant regulations?

Belgium	Royal Decree of 20th July 2001 on the protection of workers, public and environment against the hazards of ionising radiation.

France	Article R.4451-11 of French Labour Code.
Greece	Dose constraints are mentioned in the paragraphs 1.1.3b and 1.4 and 1.9 of the Greek radiation protection regulations.
Ireland	Radiological Protection Act, 1991 (Ionising Radiation) Order, 2000.
Luxembourg	Article 5.1.6 in the national radiation protection regulation which implements the EU Directive (Grand-ducal regulation of 14 December 2000 concerning the protection of the population against the dangers arising from ionising radiation).
Norway	Act on Radiation Protection and Use of Radiation (No. 36 of 12 May 2000), effective 1st January 2004.
Slovenia	Ionising Radiation Protection and Nuclear Safety Act Off. Gaz. 67/2002, amendments 110/2002-ZGO-1, 24/2003, 50/2003-UPB1, 46/2004, 102/2004-UPB2, 70/2008-ZVO-1B Decree on dose limits, radioactive contamination and intervention levels, Off. Gaz. of Rep, of Slovenia 49/2004.
Spain	Article 6º of Decree 6 July 2001 on "Health Radiological Protection against Ionizing Radiation" (Spanish Official State Gazette, 2001).
Sweden	SSMFS 2008:[Strålsäkerhetsmyndighetens föreskrifter om grundläggande bestämmelser för skydd av arbetstagare och allmänhet vid verksamhet med joniserande strålning, Rättelseblad SSMFS 2008:51, bilaga 2 (www.stralsakerhetsmyndigheten.se/Publikationer/Forfattning/SSMFS-2008/SSMFS-200851/)] (introduces the concept), SSM FS 2008:11 (0,1 mSv/y), SSM FS 2008:33, SSM FS 2008:25, SSM FS 2008:27, SSM FS 2008:28 and SSM FS 2008:40 (dose rate limits for equipment, storage and certain activities/practices) [ref. as in Section VI].
Switzerland	N/A
United Kingdom	Ionising Radiations Regulations 1999, Statutory instrument 3232 (Stationery Office, 2000).

5. Please provide (in English) the actual wording used in the regulations?

Belgium	No information provided
France	A qualified expert in radiation protection shall establish dose objectives for individual and collectives doses for a given task. These dose objectives must be established at a level as low as possibly achievable taking into account the available techniques and the nature of the operation…and in any case at a level not exceeding the dose limits.
Greece	Dose constraints: dose levels designed to limit the expected and potential exposures arising from a defined practice or defined source in the context of a practice. These levels are used at the radiation protection planning stage for optimisation purposes and are either laid down in these Regulations or approved as the case may be by the GAEC.
Ireland	Dose constraint: *a restriction on the prospective doses to individuals, which may result from a defined source, for use at the planning stage in radiation protection whenever optimisation is involved.*
	Article 9 (5) S.I. 125 of 2000: The undertaking shall, where appropriate, use dose constraints in restricting exposure to ionising radiation pursuant to paragraph (1) [Optimisation/ALARA] (Radiological Protection Act, 1991).
Luxembourg	Dose constraints are defined as a dose restriction related to a source, a task or a practise.
Norway	No reference to occupational protection. Article 16: The undertaking shall plan shielding and radiation use so as to prevent irradiation of members of the

	general public which may involve individuals being exposed to more than 0.25 mSv per year.
Slovenia	Ionising Radiation Protection and Nuclear Safety Act: Article 3.8: Dose constraint shall mean a restriction on the prospective dose to individual which may result from a defined type of radiation source. Dose constraint is used at the planning stage of the optimisation of radiation protection. Article 17: The person carrying out a radiation practice must: – use dose constraints in the optimisation of radiation protection, – ensure that due to a radiation practice doses for exposed workers, apprentice, students and members of the public do not exceed the determined dose limits. Decree on dose limits, radioactive contamination and intervention levels, Off. Gaz. of Rep, of Slovenia 49/2004 [Decree on dose limits, radioactive contamination and intervention levels, Off. Gaz. of Rep, of Slovenia 49/2004] "Article 11: 1) Dose constraints are authorised or operational dose limits or values of radiation quantities for a specific task in scope of a radiation practice or for use of a specific source. 2) Authorised dose limits or values of radiation quantities from the previous paragraph are determined by regulatory authority while operational dose limits or values of radiation quantities from the previous paragraph are determined by authorised radiation protection expert. 3) Regulatory authority determines dose constraints for a specific task in scope of a radiation practice based on data about measurements of actually received individual or collective effective or equivalent doses to workers or general population from existing radiation practices around sources with comparable working conditions, taking into account estimated individual or collective effective or equivalent doses that would be received by workers and general population if additional protective measures were introduced. 4) Social and economic factors related to a specific radiation practice must be taken into consideration by the regulatory authority when setting dose constraints."
Spain	Dose constraint must be used, where appropriate, within the context of optimisation of radiological protection, taking in account the recommendations the national regulatory authority, Nuclear Safety Council (CSN). These dose constraints can be assessed and approved by CSN
Sweden	*Example*: Buildings should be designed in such a way that the possibility to achieve doses in excess of 0,1 mSv per year is low outside controlled or supervised areas. In the process of planning a practice or in a single case, the Radiation Safety Authority has the right to establish a dose constraint, by which is meant an exposure restriction to individuals from a given source.
Switzerland	"If the effective dose determined over the monitoring period is greater than 2 mSv or the equivalent dose to an organ is greater than 10 mSv, this must be reported by the personal dosimetry laboratory to the licence holder and to the competent supervisory authority (FOPH or Suva) no later than ten calendar days after receipt of the dosimeter."
United Kingdom	IRR99 Reg 8(3) – "*Where it is appropriate to do so at the planning stage of radiation protection, dose constraints shall be used in restricting exposure to*

	ionising radiation pursuant to paragraph (1) [i.e. ALARP requirement]" (Stationery Office, 2000).

6. For what industries, processes, tasks, types of workers – all workers? the most exposed workers? specific categories of workers? etc. – are dose constraints used?

Belgium	To date, dose constraints have only been used for determining the release limits, both liquid and gaseous, for radioactive materials for major nuclear installations and have not been applied outside the nuclear sector. The Belgium regulatory authority is considering introducing generic dose constraints in the non-destructive testing sector in the future.
France	All workers for all operations in a controlled area.
Greece	The dose constraints concern both the public and the radiation workers and they are applied in the totality of the practices implementing exposure to ionising radiations.
Ireland	Dose constraints are applicable to all occupationally exposed workers, regardless of the nature of their work activities.
Luxembourg	Not used
Norway	Only used for non- radiation workers, typically in hospitals, industrial sites etc or the general public.
Slovenia	Dose constraints are applicable to all occupationally exposed workers. They are determined case by case for each radiation practice individually.
Spain	Workers in industrial radiography facilities.
Sweden	In the regulations on shielding in premises/rooms used for diagnostic or therapeutic purposes a dose constraint is used (SSM, 2008c). This is both in the medical and veterinarian sector. The dose constraint is valid for both staff and public.
Switzerland	This concept is used for all occupationally exposed persons.
United Kingdom	Applies to all occupational exposures. However, guidance [ref.] says: "*Dose constraints for occupational exposure are only likely to be appropriate where individual doses from a single type of radiation source will be a significant fraction of the dose limit (i.e. at the rate of a few mSv a year). Dose constraints are not likely to be appropriate for occupational exposures resulting from the following types of work with ionising radiation:* *(a) diagnostic radiology, nuclear medicine, most radiotherapy and other medical exposures;* *(b) most work in the non-nuclear industrial sectors; and* *(c) teaching and most research activities;* *where employee doses tend to be low. The main exception would be for special types of work (e.g. some interventional radiology), where effective doses are likely to be more than a few mSv a year.* *Even in specialised areas, such as industrial radiography, where individual doses are sometimes relatively high, it may not be appropriate to establish dose constraints for planning individual jobs unless adequate dose information is available for that type of work. If the radiation employer has such information, it should be feasible to choose a dose constraint which is representative of a well-managed operation, for example radiography of steam tubes during a conventional power station outage.*"

7. How are dose constraints used in practice?

Belgium	Not used for occupational protection.
France	As reference levels
Greece	Dose constraints are set for internal, external exposures, as well as for the combination of them. More specifically: • In the case of external exposure of the whole body or of a substantial fraction of the body, the dose limits laid down in paragraphs 1.2.1, 1.2.2 and 1.3.2 shall be deemed to be complied with if the requirements laid down in Annex II of the Regulation are met. • In the case of internal exposure, the dose limits laid down in paragraph 1.2.1, 1.2.2 and 1.3.2 shall be deemed to be complied with of the values of annual intake by inhalation and ingestion in any single year do not exceed six-tenths of the limits of the effective dose estimated using the tables contained in Annex III. a) The three tables in Annex III to this Regulation indicate the appropriate dose factors in respect of the committed effective doses for workers and the public per unit of the relevant radionuclide inhaled or ingested. b) When there is a mixture of radionuclides, the methods given in Annex III, paragraph 2, to the Regulations shall be used. • In the case of combinations of external exposure of the body or a substantial fraction of the body and internal radioactive contamination by one or more radionuclides, the limits laid down in paragraphs 1.2.1, 1.2.2 and 1.3.2 shall be deemed to be complied with if the requirements laid down in Annex II of these Regulations met. (Official Gazette, 2001).
Ireland	Dose constraints must be used in the design phase of building/retrofitting any new facility. The applicant applying for a licence for the new facility must be able to demonstrate to the regulatory authority that the building will be designed in such a way that no occupationally exposed worker will be expected to receive a dose exceeding the dose constraint. However once the building is completed, and the licence issued, the dose constraints are not enforceable – only the dose limits are enforceable.
Luxembourg	Not used
Norway	Not used for occupational protection
Slovenia	"*Evaluation of the protection of exposed workers against radiation*" is a document that has to be written by a licensee in co-operation with an independent authorised radiation protection expert for each radiation practice (licensee) separately. Part of the document is dedicated to dose constraints as proposed for the specific practice (based on dose rates, estimated workload...). The document has to be approved by the regulatory authority.
Spain	As reference values

Sweden	For the design of new diagnostic or therapeutic facilities in the medical and veterinary sectors, the regulations require the shielding in the proposed facility to meet a dose constraint of 0.1 mSv in order to optimise the protection of workers and members of the public (SSM FS 2008:11 and SSM FS 2008:33) [As per Section VI]. For certain equipment or work activities the regulations also provide for an instantaneous dose rate limit, based upon the relevant dose limit, to be set by the regulatory authority. In these cases the licensee must define local rules where he can choose to use these constraints (SSM FS 2008:25, SSM FS 2008:27, SSM FS 2008:28 and SSM FS 2008:40) [As per Section VI]. In practice these are called limits and are treated as such by the regulatory authority.
Switzerland	In the medical/research sector: If a worker exceeds the notification threshold (monthly dose), a questionnaire has to be answered, explaining the reason for the elevated dose and suggesting optimisations. This ensures that the worker is aware of his accumulation of doses or remembers a potential faulty manipulation. In the (non-nuclear) industry sector monthly values higher than the notification threshold are rare. Each dose exceeding this threshold is discussed personally with the worker or responsible radiation protection expert.
United Kingdom	A dose constraint is an upper level of individual dose specified by the employer for use at the design or planning stage. It is one of many tools for helping to restrict individual exposures as far as reasonably practicable. Dose constraints may be used to consider the best plan or design for an individual task or event or the introduction of a new facility. However, they are not intended to be used as investigation levels once a decision has been taken about the most appropriate design or plan. However, for occupational exposure, dose constraints may only be appropriate in a limited number of situations (see 6 above). The need to establish dose constraints is best determined as part of the risk assessment process.

8. Why are dose constraints introduced?

Belgium	Transposition of EU-Directive
France	Because of an obligation of transposition of European Directives and implementation of ALARA principle.
Greece	The requirement for the introduction of the dose constraints derives from the Optimisation principle and concerns the protection of the workers and the public.
Ireland	They come from the transposition of the EU Directive.
Luxembourg	Transposed from EU Directive
Norway	No information provided
Slovenia	Dose constraints have been used for several decades as a tool for optimisation of radiation practices.
Spain	They are introduced for application of the Law, in the context of optimisation of radiological protection.
Sweden	The dose rate limits are older than the constraint formalism of today. The constraint of SSMFS 2008:11 [As per Section VI] assigned for diagnostic vicinities is set to limit the possible dose commitment from that kind of source in relation to other sources constituting the total individual dose.
Switzerland	To be able to react before the yearly dose limit is reached. To raise the workers awareness for his elevated doses.

United Kingdom	Dose constraints are meant to represent levels which are normally obtainable in the particular type of work activity in well-managed operations using effective physical controls and systems of work to restrict exposure.

9. What are the benefits of introducing dose constraints?

Belgium	N/A
France	An optimisation tool
Greece	Dose constraints are an effective means for radiation protection optimisation, since they result in decreased doses to the workers and the public.
Ireland	They ensure that new facilities are designed so that the optimisation process commences at the design phase.
Luxembourg	N/A
Norway	Protection of the public
Slovenia	They are used as estimated upper limits of exposure under normal conditions. As such they provide means for identification of practices with potentially excessive exposure, triggering a review of such practices. They thus provide a useful optimisation tool.
Spain	The optimisation of radiation protection.
Sweden	More clear regulation and guide for optimisation in areas of special concern.
Switzerland	The possibility to avoid high accumulated doses. The implementation of optimisations.
United Kingdom	Help in the planning process of new designs and activities.

10. Who sets dose constraint (utilities or authorities)?

Belgium	The regulations provide for the regulatory authority to set dose constraints in the context of optimisation of protection of workers, members of the public and the environment.
France	French regulations establish the obligation by the employer to set up dose objectives at a level as low as possible. Numerical values for these dose objectives are set up by the operators and discussed with the authorities.
Greece	General dose constraints are set by the GAEC or the regulations and special dose constraints are set by the utilities.
Ireland	Dose constraints are set by the regulatory authority.
Luxembourg	The regulation state that the competent authority may define dose constraints within the authorisation in order to optimise radiation protection.
Norway	Not used for occupational protection. Value of 0.25 mSv/y set in regulations for public.
Slovenia	Dose constraints can either be “authorised” or “operational” for either practices or for specific sources. In the case of authorised values the regulatory authority sets them based upon measurements of actual doses received, either individual or collective, from existing radiation protection practices with comparable working conditions and based upon comparison with estimated doses received after the introduction of additional protection measures. For the operational values, an authorised radiation protection expert must determine the values to be used, based upon doses rates, workloads etc, and these have to be formally recorded in “Evaluation of the protection of exposed workers against radiation”, a document required from each licensee.
Spain	Doses constraints are set by the Spanish Regulatory Authority through an agreement between the applicant and Nuclear Safety Council (CSN).

Sweden	Regulations provide values for dose constraints in the design of diagnostic or therapeutic facilities in the medical and veterinary sectors. For certain equipment or work activities the regulatory authority can define limits.
Switzerland	The authorities
United Kingdom	The employer undertaking the work.

11. How are dose constraints set e.g. for a set of sources or for individual sources?

Belgium	They can either be generic in value for radioactive sources or activities involving the use of ionising radiation or else specific and included on the details of a licence issued to a facility.
France	Dose objectives are established for those operations taking place in a controlled area.
Greece	General dose constraints are set for a set of sources and special dose constraints for individual sources respectively.
Ireland	Dose constraints are set for an individual source.
Luxembourg	Dose constraints are defined in the regulations as a dose restriction related to a source, a practice or a task. In practice they are not used.
Norway	Not used for occupational exposure.
Slovenia	Dose constraint is authorised or operational dose limit for radiation practice or for use of specific source.
Spain	Doses constraints are established for tasks, practices.
Sweden	Mainly for sources.
Switzerland	For a whole sector (e.g. medical sector).
United Kingdom	Where an employer decides it is appropriate to establish dose constraints for particular types of work, these could be based on past operating experience and on any recommendations from relevant professional bodies or trade associations. In general, the value assigned to a dose constraint is intended to represent a level of dose (or some other measurable quantity) which ought to be achieved in a well-managed practice. Realistic predictions of individual doses associated with any proposed control measures for restricting exposure would be compared with the value selected for the dose constraint. If the predicted doses exceeded the value of the relevant dose constraint, the radiation employer would normally be expected to choose better control measures. These should then lead to predicted doses below the dose constraint. Therefore, a dose constraint should help to filter out options for radiation protection that could lead to unreasonably high levels of individual dose, even though the collective dose for the workforce as a whole is optimised. In some cases, the radiation employer may decide that it is acceptable for predicted doses to exceed the dose constraint where, for example, other health and safety risks have to be taken into account in selecting the most appropriate control measures.

12. Are dose constraints "misused", for example implicitly or explicitly as secondary limits (to dose limits)?

Belgium	N/A
France	As these dose objectives are not numerically fixed by the authorities, the

	likelihood to be "misused" is reduced. Moreover, the difference between a dose objective and a dose limit is clearly indicated in the regulations (see above).
Greece	No
Ireland	No – it is clear that they are only used during the design stage of a new facility and have no legal standing once the facility is operational.
Luxembourg	N/A
Norway	N/A
Slovenia	No
Spain	It is an appropriate value not a secondary limit.
Sweden	They are essentially used as secondary limits.
Switzerland	No
United Kingdom	No

13. Are dose constraints used as a regulatory instrument?

Belgium	No – not for occupational protection.
France	The question is not clear. In France, as far as its part of the regulations, the set up and the implementation of these dose objectives are checked and discussed at the time of the instruction of the authorisation and during inspections.
Greece	Yes
Ireland	Yes – they are used as a regulatory tool to ensure that optimisation is incorporated into all new facilities from the initial design stage.
Luxembourg	No
Norway	No
Slovenia	Yes
Spain	It can be. These values are content in the Operation Manual of the facility. This document is mandatory to work the facility.
Sweden	Yes
Switzerland	Not directly
United Kingdom	Yes

14. Who manages performance against dose constraints and other occupational radiation protection criteria?

Belgium	N/A
France	The management of worker radiation protection is the responsibility of the employer of the workers.
Greece	At the national level the GAEC and locally the Radiation Protection Expert (RPE) or the responsible of the sources.
Ireland	There is no on-going performance against dose constraint as they are only used at the initial design stage. The Radiation Protection Adviser (Qualified Expert) must be involved in the design of the facility and has to demonstrate to the Regulatory Authority how the dose constraint will be met.
Luxembourg	N/A
Norway	N/A
Slovenia	Radiation protection officers in cooperation with radiation protection experts and in some cases regulatory authority.
Spain	The qualified expert in radiation protection.
Sweden	The licensee has to follow all regulations and is supervised by the authority in doing so. The management may defined local rules as part in the process of

	following regulations and to optimise dose. Locally defined constraints may be a result.
Switzerland	The authorities.
United Kingdom	The employer doing the work. Overseen by the regulatory authority through inspections.

15. In what context are dose constraints set: for sites (refers to design) or for tasks (refers to operation)?

Belgium	In the context of protection of members of the public (and the environment), dose constraints are used in the design phase. In the context of protection of workers, dose constraints are used in the operational phase.
France	In France, occupational dose objectives are established for "task" (operations).
Greece	For all approved practices or activities, the GAEC shall lay down general dose constraints for the protection of the public and workers. Moreover, for each source, in the context of a practice or activity, the radiation protection officer shall lay down special dose constraints at the planning stage, which shall be approved by the GAEC.
Ireland	They are applicable to sites/facilities, and used only at the design stage.
Luxembourg	Not used
Norway	Not used
Slovenia	In non-nuclear sector they are set for tasks (refer to operation).
Spain	For tasks refer to operation
Sweden	See answer to question 7.
Switzerland	Both. For example the whole medical sector has the same constraints.
United Kingdom	Both for design of new facilities and planning tasks, although as stated in question 6, very infrequently used in non-nuclear industrial sectors.

16. How are dose constraints fixed, implemented, and controlled in each of these cases?

Belgium	N/A
France	Already answered: fixed, and implemented by the employer/operator, controlled by the authority.
Greece	In the event of the dose constraints being exceeded systematically, the GAEC shall be immediately informed by the head of laboratory and the radiation protection optimisation measures shall be re-examined and/or reviewed. The implementation of the reviewed measures shall be approved by the GAEC.
Ireland	They are fixed by the regulatory authority and applicants for a licence must demonstrate to the authority how their design will meet the dose constraints. They are not enforceable once the facility has been built.
Luxembourg	N/A
Norway	N/A
Slovenia	For implementation see answers to questions 7 and 10. If dose constrains are exceeded the licensee must report it to the regulatory authority and review the practice in cooperation with an independent authorised radiation protection expert. Based on the results of the review the radiation protection measures have to be re-optimised or, when this is not possible, new dose constraints should be proposed. In addition an action level of 1.6 mSv/m is implemented when dosimetry service must report to the regulatory authority immediately.
Spain	Fixed and implemented by the qualify expert in radiation protection and

	controlled by the authority.
Sweden	See answer to question 7.
Switzerland	Dosimetry services are obligated to report values higher than the constraints. The supervisory authorities evaluate the doses and demand explanations or possible optimisations.
United Kingdom	See question 11.

17. In practice, has enforcing (individual) dose constraints resulted in negative consequences (e.g. higher collective doses, increased costs, etc.)?

Belgium	No information provided
France	Not as far as collective dose is concerned as dose objectives has to be established for both, individual and collective doses.
Greece	Dose constraints seem to increase the cost for the installations to be constructed due to the increased shielding requirements.
Ireland	Not aware of this happening
Luxembourg	No information provided
Norway	No information provided
Slovenia	No
Spain	No
Sweden	They have resulted in lower doses at an economical cost (lead in walls etc.).
Switzerland	No, not to our knowledge.
United Kingdom	Not aware of this happening.

18. What approaches have proven successful in discussing dose constraints between regulatory authorities and licensees?

Belgium	N/A
France	Feedback of operating experience
Greece	The effectiveness and the necessity of the dose constraints is discussed with the licensees during the GAEC on site inspections and it is based on the evaluation results of the implemented radiation protection measures.
Ireland	Dose constraints would have been discussed and agreed by the Regulatory Authority's medical radiation advisory committee on which many radiation protection advisers (qualified experts) would be represented.
Luxembourg	No information provided
Norway	N/A
Slovenia	Independent authorised radiation protection experts that must be involved in setting the dose constraints act as highly qualified link between the regulatory authority and the licensees.
Spain	Operation experience
Sweden	No information provided
Switzerland	To explain them why we use these notification threshold values and why we control doses higher than these values.
United Kingdom	As stated in question 6, very infrequently used in non-nuclear industrial sectors.

19. Have you any experience in balancing occupational radiation protection dose constraints with the management of other risks (e.g. industrial, chemical/biological safety issues)?

Belgium	No information provided
France	No experience

Greece	No
Ireland	No
Luxembourg	No information provided
Norway	No information provided
Slovenia	No
Spain	No
Sweden	No information provided
Switzerland	No
United Kingdom	No

Appendix 2: ISOE Forum Answers on Use of Individual Dose Constraints or Constraint-Like Concepts in the Nuclear Energy Sector

Summary:

Country	Operator	Individual dose constraints or constraint-like concepts
Canada	Ontario Power Generation	Two levels of individual dose constraints: - Exposure Control Level (ECL). - Administrative Dose Limit (ADL). Exposure control levels for nuclear energy workers: - Whole body including tritium committed dose: 1 rem/calendar year (10 mSv). - Tritium committed dose: 0.150 rem (1.50 mSv). - Skin: 10 rem/calendar year (100 mSv). - Hands and feet: 25 rem/calendar year (250 mSv).
Spain	Cofrentes NPP	- Investigation: 10 mSv/y (not apply in refuelling outages). - Intervention: 18 mSv/y or 90 mSv/5 years.
Sweden	Forsmark NPP	- Planned annual dose shall not exceed 10 mSv. - No actual individual annual dose shall exceed 15 mSv. - Not more than 1% of the actual individual annual doses shall exceed 10 mSv. - No internal contamination exceeding 0,3 mSv.
	Oskarshamn NPP	- Dose/day: Planning value = 3 mSv; Check point = 2.5 mSv. - Dose/month: Planning value = 10.0 mSv; Check point = 8.0 mSv. - Dose/year: Planning value = 20.0 mSv; Check point = 18.0 mSv. - In addition, dose rate constraint < 4mSv/h, that are used as a complement.
	Ringhals NPP	- Authority limits: 50 mSv/y (calendar) and 100 mSv/5y (rolling). - In Ringhals: 10 mSv/y. - Some contractors: 20 mSv/y.

Country	Operator	Individual dose constraints or constraint-like concepts
Switzerland	Leibstadt NPP	- Dose constraint: 10 mSv/y for plant staff. - For contractors, dose constraint determined by the contractors' employer (not override 20 mSv/y).
UK	Sizewell B NPP	- The utility (British Energy) has adopted a Company Dose Restriction Level (CDRL) of 10 mSv/y. - The national dose limit in UK is 20 mSv/y.
USA	Byron Nuclear Generating Station	- Admin Limit: 2 rem (20 mSv). - Work group supervisor and radiation protection manager approval: 2-3 rem (20-30 mSv). - Site vice-president approval: 3-4 rem (30-40 mSv). - Executive vice-president approval 4-5 rem, (40-50 mSv). - Legal limit: 5 rem (50 mSv).
	Clinton NPP	- Federal limit: 5 rem/y (50 mSv). - Utility imposes 80% of that limit administratively and electronically reducing it to 4 rem/ y (40 mSv). - Establish a 2 rem/y (20 mSv) limit on radiation workers that may be exceeded only with permission of the RPM.
	PPL Susquehanna	- Regulatory limit remains at 5 rem/y (50 mSv/y). - The regulatory authority is considering adoption of a limit of 2 rem/y (20 mSv/y) or 100 mSv/5 y. Station administrative limits: - Personnel dose limit: 2 rem/y (20 mSv/y). - Authorisation required: for an individual to exceed 2 rem/y (20 mSv/y) annual exposure. - Additional authorisation required: for an individual to exceed 3 rem/y (30 mSv/y) annual exposure. - While an authorisation process exists to grant an extension to exceed 4 rem/y (40 mSv/y), station management has stated that it would be very unlikely to grant such a request, absent a very compelling argument for such an extension. - While a process exists in the regulations for a planned special exposure to exceed 5 rem/y (50 mSv/y), PPL does not expect to use that process and has procedurally stated that the process would not be used.

Detailed description:

Canada: Ontario Power Generation

Ontario Power Generation (OPG) is the public electricity generating company in Ontario, Canada operating 10 CANDU reactors. Our radiation protection procedures include 2 levels of individual dose constraints, termed the Exposure Control Level (ECL) and the (higher) Administrative Dose Limit (ADL). Different levels of management approval are required to exceed these levels, and exceeding an ADL without approval is reportable to our regulator, the CNSC.

The following table summarises the ECLs, which vary with both the source of exposure and the worker category. NEW is the Canadian designation of a Nuclear Energy Worker; non-NEWs are those workers who have no reasonable probability of receiving more than 1 mSv committed effective dose in a year. (CY refers to a calendar year).

Organ or Tissue	NEW	Pregnant NEW rem/balance of pregnancy[1]	Nursing NEW rem/CY for balance of nursing[2]	Non-NEWs (Public) (rem/CY)
Whole Body (Effective Dose) Including tritium committed dose	1 rem/CY	0.010	1 (no radioactive work with risk of tritium exposure or internal contamination is allowed)	0.010
Tritium committed Dose	0.150 rem	N/A	N/A	N/A
Skin	10 rem/CY	N/A	10	N/A
Hands and Feet	25 rem/CY	N/A	25	N/A

Note: (1) ECL will only be applied to pregnant NEWs if notification of pregnancy has been given in accordance with N-PROC-RA-0010, Facility Access and Working Rights (Radiological)

(2) ECL will only be applied to nursing NEWs if notification of nursing has been given in accordance with N-PROC-RA-0010.

The second, following table summarises the ADLs, which also vary with classification of the worker. The "Parts D&G employees" are nuclear workers but those who are not expected to receive large doses in their normal routines. ADLs are provided only for committed effective (whole body) doses, and for both a single year and for a 5-year rolling average.

	Whole Body Dose Limits in Ontario Power Generation (rem/CY)		
	Nuclear Part D&G Employees	Other Ontario Power Generation Employees	Contract and Building Trades Union Employees
NEW	2	2	4
NEW with a lifetime Whole Body dose greater than 50 rem	1	1	N/A
Non-NEW	0.050	0.050	0.050
Whole Body Dose Limits (rem/rolling 5 CY)			
NEW	5	9	9

Japan: Views of all utilities

Under Japanese law, individual dose limits are set at 50 mSv/y and 100 mSv/5 years (for each five year period from April 1, 2001). As might be expected and in the spirit of the ALARA, utilities take measures to keep individual doses at or below the legal limits, as well as measures to reduce radiation exposure to achieve lower individual doses.

Spain: Cofrentes NPP

Dose Administrative Levels for professional workers type A:

- Investigation: 10 mSv/y (not apply in refuelling outages)
- Intervention: 18 mS/y or 90 mSv/5 years

Sweden: Forsmark NPP

ALARA programme[7]:

- Planned annual dose for any individual shall not exceed 10 mSv
- No actual individual annual dose shall exceed 15 mSv
- Not more than 1% of the actual individual annual doses shall exceed 10 mSv[8]
- No internal contamination exceeding 0.3 mSv (which is the minimum regulatory reporting limit) shall occur

Alarm settings in Electronic Portable Dosimeter (EPD)

- Dose alarm per entry to Radiation Controlled Area (RCA) = 0.5 mSv, may for specific work be altered only by radiation protection personnel

Arrangements for external personnel (contractors)

Contractors should not receive on the Forsmark site an individual dose higher than 15 mSv in one calendar year (this means that they might be exposed to 18 mSv (or up to 50 mSv) for the full year if they are working in another plant).

Follow-up procedure in the case of exceeding of 15 mSv in one calendar year

By still being within the legal dose limits, no action will be taken by the regulator. The reason for the dose will be internally investigated (type of work, work methods, tools etc) and countermeasures for the future implemented (if such can be defined). The individual will of course not be punished in any way! It may also be the case that it was deliberately judged by the radiation protection manager that it is optimised and planned that the individual exceeded 15 mSv, a decision that shall be documented.

Follow-up procedure in the case of exceeding of 18 mSv in one calendar year

Generally, the contractor is not allowed to perform additional work within RCA.

7. The below figures apply fully only for our own personnel. For external personnel only for work performed in Forsmark (there is no possibility for Company to regulate external companies dose planning, although by contracts and discussions it is believed that much may be achieved).

8. 1% of individuals exposed in Forsmark (and for own personnel doses added taken elsewhere)

Sweden: Oskarshamn NPP

In OKG (Oskarshamn Nuclear Power Plant-Sweden) we have several constraints that are used, see below.

Dose/day:
Planning value = 3 mSv
Check point = 2.5 mSv

Dose / month:
Planning value = 10.0 mSv
Check point = 8.0 mSv

Dose / year:
Planning value = 20.0 mSv
Check point = 18.0 mSv

In addition to these constraints we also have a dose rate constraint, less than 4mSv/h, that are used as a complement. A pregnant woman will be placed at a work place that will not cause a dose of >1mSv the remaining period of the pregnancy.

Sweden: Ringhals NPP

The Authority limits in Sweden are 50 mSv/y (calendar) and 100 mSv/5y (rolling).

Dose objectives for Company- and Contractor personnel at Ringhals, this is valid for a total annual individual dose exposure (not only dose taken at Ringhals)

The objective is to confine and plan for maximum 20 mSv annual dose. For a single year plans can be made to exceed 20 mSv but it has to be decided between work management and radiation protection management.

For separate individuals and occupational groups that frequently exceed 20 mSv, special measures will be taken to evaluate work methods in order to reduce the individual's dose effectively.

Reasons for individuals nearly reaching 20 mSv annual doses shall be investigated in order to take actions to reduce the dose.

It is expected that the radiation protection manager co-operate with work management to analyse the reasons for individual doses exceeding or if individual doses are expected to exceed 10 mSv annual dose.

We have a dose constraint for women in fertile age at 10 mSv/ 2 month.

Examples of objectives, dose taken at Ringhals, from our internal environmental plans of action by department are:

- No individuals shall exceed 10 mSv/y
- Focus on exposed occupational groups where individuals annually are exceeding 10 mSv/y
- Dose exposure shall be kept down, less than 10 mSv/y

These items may sound a bit contradictory but the purpose is to encourage different departments to take responsibility for department doses and take actions to meet ALARA by reducing individual doses.

This standpoint concerns both plant – and contractor personnel but the contractor have the responsibility to look after their interest in handling their own crew's individual doses.

Some contractors have their own constraints, which for example can be "no company or consultant personnel should exceed 20 mSv/y, doses 14-18 mSv are allowed just in exceptional cases. Company management is informed when 14 mSv is reached and if the threshold value at 18 mSv is reached for the last 12 month no more dose is allowed".

Additional dose constraints are the dose alarm and dose rate alarms in the electronic dosimeters. These alarms are preset at 2 mSv/h and 3 mSv/h, but can be increased or decreased by radiation protection managers.

The best dose constraint is still an active dialogue between radiation protection officers, work managers and workers as well as an interest in keeping doses low throughout the organisation.

Switzerland: Leibstadt NPP

At Leibstadt Nuclear Power Plant (KKL) we have a dose constraint of 10 mSv/y for plant staff. For contractors we require a dose constraint determined by the contractors' employer. It cannot override 20 mSv/y. (e.g. a dose constraint for a US citizen of 30 mSv would not be acceptable).

United Kingdom: Sizewell B NPP

The utility (British Energy (BE)) has adopted a Company Dose Restriction Level (CDRL) of 10 mSv/y for work carried out at the utility sites.

In exceptional circumstances doses in excess of the CDRL of 10 mSv/y can be sanctioned by the Corporate Director of Safety & Regulation.

In very exceptional circumstances (in practice this has never been applied) doses in excess of 15 mSv/y can be sanctioned by the chief nuclear officer of the utility.

The national dose limit in UK is 20 mSv/y.

Q: How to you verify 10mSv/y: Are all sites from BE connected regarding the collect of individual doses? i.e. If someone (BE staff or contractor) comes to work on Sizewell B, do you know the dose he received in the another BE site?

A: When a worker is planning to arrive at the site we ask the individual (or more usually the company) to complete an RCA request form. This asks for the worker's dose for the year to date. Should the annual dose to date be significant (more than 5 mSv) then we would ask for more detail about the breakdown of the doses. We also have access to a company-wide, on-line, dose report that sums doses across all BE sites. For outside workers from the EU (except France) it is easy to verify doses using the radiation passbook data. US workers bring an NRC form 4 and anyway never work at other BE sites.

Q: There is an individual dose constraint of 4 mSv per outage. Is that specific to Sizewell?

A: About 14 months before each outage we set some radiation protection targets including an individual dose target. This is without a detailed work breakdown. We use this when reviewing detailed work scope and use it as a guide, for example to decide upon necessary contract crew sizes. If we decide that work will result in doses above the constraint then we would critically assess the dose reduction measures to decide whether anything more could be done to reduce individual doses. For the next outage (and the last outage) we set a 4 mSv individual dose "constraint".

USA: Byron Nuclear Generating Station, USA

2 rem (20 mSv) Administrative Limit
2-3 rem (20-30 mSv), Work group supervisor and radiation protection manager approval
3-4 rem (30-40 mSv), Site vice-president approval
4-5 rem (40-50 mSv), Executive vice-president approval
5 rem (50 mSv), legal limit.

USA: Clinton NPP

We have federal limit of 5 rem/y (50 mSv/y), our utility imposes 80% of that limit administratively and electronically reducing it to 4 rem/y (40 mSv/y). As fleet we further establish a 2 rem/y (20 mSv/y) limit on radiation workers that may be exceeded only with permission of the radiation protection manager. Pragmatically, the only individuals who need the extension are the individuals who inspect vessel nozzle welds on a BWR for my plant.

On a generic RWP and Specific level there are RWP limits for dose as well as dose rate which are assigned other individuals electronic dosimeter. As an example our radiation protection generic RWP has a 20 mrem (0.2 mSv) high dose alarm and a 200 mrem/h (2 mSv/h) dose rate alarm.

The RWP has a dose limit based on the work estimate and there is an RWP dose lockout at 80% of the RWP limit.

When there is hot (e.g high radiation level work), the individual is assigned a specific limit and they are entered into the individual's electronic dosimeter by the radiation protection technician.

USA: PPL Susquehanna NPP

Our regulatory limit remains at 5 rem/y (50 mSv/y). The regulatory authority is considering adoption of a limit of 2 rem/y (20 mSv/y) or 100 mSv/5y.

Our station administrative limits are as follows:

1. The management expectation is that personnel will be limited to 2 rem/y (20 mSv/y) exposure at PPL Susquehanna.

2. Authorisation is required for an individual to exceed 2 rem/y (20 mSv/y) annual exposure.

3. Additional authorisation is required for an individual to exceed 3 rem/y (30 mSv/y) annual exposure.

4. While an authorisation process exists to grant an extension to exceed 4 rem/y (40 mSv/y), station management has stated that it would be very unlikely to grant such a request, absent a very compelling argument for such an extension.

5. While a process exists in the regulations for a planned special exposure to exceed 5 rem/y (50 mSv/y), PPL does not expect to use that process and has procedurally stated that the process would not be used.

Of course, during a declared emergency, different rules exist as necessary. The above limits apply in the case of normal operations and anticipated operational occurrences and those declared emergencies which can be managed within the normal regulatory process.

Appendix 3: CRPPH Expert Group on Occupational Exposure (EGOE)

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