# Personal dosimetry for occupational exposure to ionising radiation

**Gezondheidsraad**
Health Council of the Netherlands

To the Minister of Social Affairs and Employment

Subject : Presentation advisory report ‘Personal dosimetry for occupational exposure to ionising radiation’
Your reference: ARBO/M&A/2005/24261
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Dear Minister,

In recent years the practice of protection against ionising radiation has been changing. Until recently, a personal dosimeter was worn by every worker employed in a company where equipment that emits such radiation is present. A growing number of institutions, however, is abandoning these individual measurements.

This development prompted your predecessor to ask the Health Council of the Netherlands for possible health risks associated with this changing practice.

I am pleased to present you the advisory report ‘Personal dosimetry for occupational exposure to ionising radiation’ that answers this question.

The report has been drafted by one of the Health Council’s permanent expert groups, the Standing Committee on Radiation and Health.

I have sent this report today also to the Minister of Health, Welfare and Sport and to the Minister of Housing, Spatial Planning and the Environment.

The most important conclusion is that under certain conditions it is indeed possible to abandon routine personal dosimetry for some groups of workers. There are no legal or health-based objections against this practice.

However, it is important that a modified safety policy be designed for these workers. This includes the use of other methods to determine the dose of ionising radiation that they can be exposed to in exceptional situations.

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For this reason it is recommended to define a new category of workers: category C. This may include groups of workers with an exposure too low to be classified as ‘exposed workers’ according to the Decree on Radiation Protection, but that might be exposed in special circumstances and for whom therefore suitable radiation protection care is necessary.

I expect that the implementation of these proposals will improve the quality of the radiological protection care of workers.

Yours sincerely,
(signed)
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# Personal dosimetry for occupational exposure to ionising radiation

to:

the Minister of Social Affairs and Employment

the Minister of Health, Welfare and Sport

the Minister of Housing, Spatial Planning and the Environment

No. 2008/07E, The Hague, March 25, 2008

The Health Council of the Netherlands, established in 1902, is an independent scientific advisory body. Its remit is “to advise the government and Parliament on the current level of knowledge with respect to public health issues...” (Section 22, Health Act).

The Health Council receives most requests for advice from the Ministers of Health, Welfare & Sport, Housing, Spatial Planning & the Environment, Social Affairs & Employment, and Agriculture, Nature & Food Quality. The Council can publish advisory reports on its own initiative. It usually does this in order to ask attention for developments or trends that are thought to be relevant to government policy.

Most Health Council reports are prepared by multidisciplinary committees of Dutch or, sometimes, foreign experts, appointed in a personal capacity. The reports are available to the public.

The Health Council of the Netherlands is a member of the European Science Advisory Network for Health (EuSANH), a network of science advisory bodies in Europe.

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***INAHTA***

This report can be downloaded from www.healthcouncil.nl.

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# Contents

# Executive summary

### Radiological protection care is necessary

Some workers may be exposed to ionising radiation while exercising their duties because they work with or in the vicinity of equipment or substances that emit radiation. Exposure to ionising radiation may lead to adverse health effects. Therefore, adequate radiological protection is desirable for the workers involved. To safeguard a high degree of protection, this care must be tailored to suit specific needs.

### Personal dosimetry is a key tool

The regulations defined in the Decree on Radiation Protection are designed to protect workers in the Netherlands from the negative effects of exposure to ionising radiation. The decree includes provisions stipulating that the maximum allowed annual dose for those who are classified as ‘exposed worker’ may be higher than for other workers. It also prescribes specific protection and monitoring measures.

One of these measures is that ‘exposed workers’ must wear a so-called personal dosimeter. This allows the received radiation dose to be recorded for each individual worker. This is important in order to check whether the dose remains within the limits set and whether exposure has been kept as low as reasonably possible.

## Which workers require routine personal dosimetry?

In practice, the requirement for wearing personal dosimeters was implemented broadly in the Netherlands. This meant that all workers that work with sources of ionising radiation were equipped with personal dosimeters, even if they were exposed to so little radiation that they were not formally to be classified as ‘exposed workers’.

There have been recent changes to this standard practice, however. Some large institutions have decided to classify fewer employees than previously as ‘exposed workers’, and no longer provide them with personal dosimeters. They feel routine personal dosimetry is unnecessary in these cases.

This prompted the Secretary of State for Social Affairs and Employment to ask the Health Council of the Netherlands for advice regarding the possibility of routinely providing fewer workers with personal dosimeters. Does the law allow for this change of practice? Is this allowable in terms of health? And what conditions must be met if a decrease is to be permissible? In this advisory report, the Standing Committee on Radiation and Health provides answers to these questions.

## Abandoning personal dosimetry is allowable for certain workers

Changing the policies regarding who is required to wear a personal dosimeter is possible, and workers who are not actually exposed – even if they work with or in the vicinity of equipment or materials that emit ionising radiation – do not automatically need to be considered ‘exposed workers’. This releases them from the obligation of wearing a personal dosimeter. Specifically, this might include groups of workers for which it has been demonstrated that:

- the degree of exposure, including any disruptions that may reasonably be anticipated, is consistently very low (less than 0.2 milisievert per quarter), and also
- the odds of abnormal events and the potential for significantly higher exposure (more than 0.2 milisievert per event) are low.

There are no legal issues with this liberalisation of personal dosimetry policy, because it meets national and international standards. After all, the classification as ‘exposed worker’ is still based on the degree of exposure to be expected in daily practice. There are also no health concerns standing in the way of no longer wearing a personal dosimeter.

### Additional measures for these workers are desirable

In order to decrease the number of workers with personal dosimeters in a responsible fashion, a number of conditions must be met. The basic tenet is that anyone who may be exposed to ionising radiation during work is entitled to adequate personal radiation protection. This position is in agreement with previous Health Council recommendations on the subject.

Therefore, the recommendation is to create a new category of workers: category C. This category includes workers who are not classified as ‘exposed worker’, but who do work with or near equipment or substances that emit ionising radiation.

This is because they normally only experience minimal exposure, but do run the risk of being exposed to a not insignificant dose of radiation in the event of a calamity or incident. After all, they will partly be working in a zone defined as ‘controlled’ or ‘monitored’ under the Decree on Radiation Protection, where such events may occur. Therefore, they differ from workers who never work in the vicinity of sources of ionising radiation.

Exposure monitoring remains important for these new category C workers. However, this does not necessarily has to involve routine personal dosimetry. The workplace monitoring systems for monitored and controlled zones dictated by the Decree on Radiation Protection are sufficient. Additionally, a programme for radiation protection must be developed for these workers, potentially within the framework of a safety management system, in order to:

- evaluate and test whether measures and facilities for radiation protection of workers are adequate;
- verify that the criteria for classification as category C workers are met;
- determine exposure in abnormal situations or in the event of a radiological accident.

This radiation protection programme must be implemented by or under supervision of radiation protection experts.

These regulations will sufficiently formalise and secure the protection of this group of workers, while at the same time underlining the employer’s own responsibilities.

### A good risk analysis contributes to good protection

An adequate risk analysis is important to ensure that workers are assigned to the correct category. There are signs that current risk analyses are not always of sufficiently high quality. The creation of a new category of workers requiring a separate form of monitoring and protection only serves to emphasize the importance of ensuring proper categorisation. A number of concrete conditions have been formulated to this end.

For example, a good risk analysis must provide insight into the degree of personal exposure workers may experience while performing their duties. The presence and use of all potential radiation sources must be considered. When determining the odds and degree of potential exposure, measures taken to limit exposure and prevent accidents must also be taken into account. The involvement of a radiation protection expert in drafting the risk analysis is required for these reasons.

In addition to the dose to be expected under normal working and operating conditions, the odds of incidents and the likelihood workers will be exposed to radiation in the event of such incidents must be considered separately.

If these conditions are met, assignment of workers to a category will occur based on actual or risk of exposure wherever possible. Protective measures will also be suited to their situation, whether that involves routine personal dosimetry or not.

Chapter 1

# Introduction

## 1.1 Background

In order to protect workers from health risks they may run if they are exposed to ionising radiation in the workplace, standards have been created for permissible exposure.*

In the Netherlands, this is defined in the Decree on Radiation Protection.[2]

Above all else, the purpose and necessity of occupational exposure have to be examined for compatibilty with the principle of justification. Occupational exposure is only allowed if there is a valid reason for it. This means that exposure has to be reasonable with respect to the profession or the tasks performed. If this is not the case, exposure is not justified and therefore not permissible. If the conditions are met, the ALARA principle applies as a basic standard for radiation protection.**

This principle dictates that exposure for individual workers and the number of exposed persons must be kept as low as reasonably achievable. Additionally, annual dose limits are defined. The Decree on Radiation Protection also identi-

* Background information on the effects of exposure to ionising radiation may be found among others in the advisory report 'Risks of exposure to ionising radiation' published by the Health Council.[1]

** ALARA: *As Low As Reasonably Achievable.* For more information: see the *European ALARA Network* (www.eu-alara.net) and the Health Council advisory report 'Principles of radiation protection'.[3]

fies a special category of workers, the ‘exposed workers’, for whom different limits and measures apply than for other workers.

In order to allow effective control of compliance with the guidelines, the Decree on Radiation Protection dictates that a routine form of personal dosimetry is mandatory for all workers classified as ‘exposed worker’.

In the Netherlands, past practice has been to interpret the term ‘exposed worker’ with a great deal of latitude, so that many workers who may be exposed to ionising radiation in the course of performing their duties wear personal dosimeters, even if actual exposure is minimal.

Recently, however, several large institutions decided to no longer consider certain groups of workers who work with equipment or substances that emit ionising radiation as ‘exposed workers’, and to no longer equip them with personal dosimeters. Each reclassification was preceded by a risk analysis, demonstrating that by taking workplace measures the odds of exposure to levels exceeding the limits applicable to workers not classified as ‘exposed worker’ are extremely low.

Lowering the number of workers wearing personal dosimeters has a number of operational advantages. After all, measurement results must be interpreted and registered. This entails a certain workload and associated costs. But are these savings legally allowable and responsible in terms of health? Can the number of people wearing a dosimeter indeed be decreased without problems, and on what conditions?

## 1.2 Question and methods

For the State Secretary of Social Affairs and Employment, this development was reason to consult the Health Council. This advisory report answers the following questions on this subject:

1 What is the importance of personal dosimetry within radiation protection?
2 How can the guidelines on routine personal dosimetry in Dutch and European legislation be implemented in practice?
3 Is no longer equipping certain workers with personal dosimeters who used to wear them allowable in terms of health? If so, on what conditions?
4 What requirements must be met in the legally required risk analysis used to determine whether or not certain groups are classified as ‘exposed workers’?

The complete request for advice is included in Annex A of this advisory report. The report was written by the Standing Committee on Radiation and Health, a permanent committee of Health Council experts. Because the Standing Commit-

tee acted as the responsible committee in this advisory report, it will hereafter be referred to as ‘the Committee’. The members of the Committee are listed in Annex B.

## 1.3 Terminology

Certain terms in this advisory report have specific definitions. Below is an overview of the key terms and their meanings as used in this advisory report. Wherever possible, these definitions are based on those used in the Decree on Radiation Protection, but they may not always be literally identical. A number of relevant articles from the Decree on Radiation Protection are listed in Annex C.

*Personal dosimetry*: individual monitoring of exposure to ionising radiation. This may be incidental or routine.

*Routine personal dosimetry*: the legally required individual monitoring (as described in Article 87 of the Decree on Radiation Protection) that is periodically performed using dosimeters provided by a certified dosimetric service (as described in Article 8 of the Decree on Radiation Protection).

*Dosimeter*: the measurement instrument used for individual monitoring of external exposure. In the Decree on Radiation Protection, the dosimeter is referred to as a ‘personal dose control device’.

*Personal dose*: the degree of personal exposure expressed as ‘effective dose’. The unit used is the millisievert (mSv). If exposure of individual body parts is relevant, this is expressed as ‘equivalent dose’. Definitions of ‘effective dose’ and ‘equivalent dose’ can be found in Annex C. This advisory report only refers to the effective dose.

*Worker*: any individual who, according to the definition in the Decree on Radiation Protection, performs duties, be it as an employee or on the authority of an employer, or independently. According to the explanation to the Decree, the use of the phrase ‘on the authority of’ also covers interns and students.

*Exposed workers*: Workers that, according to the definition in the Decree on Radiation Protection, may be exposed to an effective dose of more than 1 mSv in one year in the course of performing their duties.

*Other workers*: Workers not classified as exposed worker.

## 1.4 Reading notes

Chapter 2 outlines the importance of personal dosimetry for the protection of workers. This will answer the first question. Chapter 3 addresses the question of whether certain groups of workers that currently wear a personal dosimeter may be freed of the obligation, given existing legal frameworks and health knowledge. The Committee thereby answers the second and third questions, and makes its recommendation on this key point. Chapter 4 describes the characteristics the mandatory risk analysis used to classify workers as ‘exposed’ or not should have. The Committee thereby answers the fourth question. Chapter 5 provides a brief overview of the key conclusions.

Chapter 2

# The importance of individual measurements

What is the basis of the existing legislation on personal dosimetry? What does it aim to achieve? In this chapter, the Committee provides a brief overview of the reasons for routine personal dosimetry for workers. The issue at hand is measuring external exposure. Internal exposure is not addressed.

## 2.1 Function of routine personal dosimetry

The importance of routine personal dosimetry for the protection of workers against the harmful effects of ionising radiation may be derived from the recommendations of the International Commission on Radiological Protection (ICRP).[4,5] These recommendations are used all over the world as the foundation for national legislation and regulations within international organisations. In a 1984 advisory report, the Health Council endorsed the ICRP's principles on this subject.[6] The ICRP recommendations are the basis for the European Directive[7] that the Decree on Radiation Protection is based on.

Routine personal dosimetry is primarily intended to systematically verify whether the dose of radiation a worker is exposed to during the performance of his or her duties meets the legal standards for dose constraints. Additionally, wearing a personal dosimeter allows checking that exposure is consistent with the ALARA principle and with ceiling values for individual dose constraints* that

* Following the ICRP recommended principle of dose constraints, in accordance with the ALARA principle.

have been defined for specific tasks and situations. This also includes local employer rules.

Additionally, measuring individual radiation doses is used to obtain data that is important for designing and implementing the correct measures to protect workers against radiation in the workplace.

Personal dosimeters can also provide valuable information in the event of radiological accidents. Based on the exposure data, the need for and type of medical treatment can be determined, as can any necessary follow-up measures. Thus, personal dosimetry also contributes to the risk inventory and evaluation prescribed by occupational health and safety laws.

Finally, routine personal dosimetry can also provide data that can be used in scientific research into the risks of exposure to ionising radiation (for example, see the international trial performed under the auspices of the International Agency for Research on Cancer[8,9]).

## 2.2 Personal dosimetry - when and for whom?

According to the ICRP, the answer to the question for which workers and under what conditions personal dosimetry is useful and necessary depends on:

- the expected level of exposure in relation to dose limits;
- the possible variations and uncertainties in the degree of exposure and in working conditions.

The ICRP recommends personal dosimetry for all workers that may be exposed, unless it is clear in advance that the dose will be consistently low and is significantly lower than the legally prescribed limits on an annual basis. The ICRP recommends looking at groups of workers with common characteristics rather than at individual workers. The recommendation is to differentiate between:

- groups that definitely require personal dosimetry;
- groups that may require personal dosimetry;
- groups that do not require personal dosimetry.

## 2.3 Conclusion

The first question, addressing the importance of personal dosimetry for radiation protection, can now be answered. The Committee endorses the reasons given by the ICRP for routinely applying personal dosimetry for certain groups of workers. This measure is primarily important for:

- checking that legally defined annual dose limits are not exceeded;

- checking that the legally prescribed ALARA principle is adhered to;
- checking that additional local requirements for individual dose constraints are met;
- testing the effectiveness of measures and facilities for worker radiation protection;
- determining the correlation between the activities and the dose incurred, and detecting trends;
- determining the individual dose after a radiological accident;
- obtaining data for scientific research into the risks of exposure to ionising radiation.

Chapter 3

# Routine personal dosimetry: only where necessary

Wearing personal dosimeters is meant to protect workers, as discussed in the previous chapter, among other things by verifying compliance with the exposure regulations. Which groups of workers are legally required to wear personal dosimeters, and are there any reasons for changing current practice? That is what this chapter is about. In order to answer this question, both the legal framework and knowledge about exposure risks are reviewed. The Committee formulates its recommendations based on these data.

## 3.1 Legislation and regulations

Is it legally allowable to exempt certain groups of workers in the Netherlands from wearing routine personal dosimeters if they wore them until recently? In order to answer this question, the Committee first provides an overview of current legislation and regulations and the practical implementation thereof. Changes in daily practice, due to which personal dosimetry is no longer considered necessary for certain groups of workers, are then examined based on these rules.

### 3.1.1 *Defining 'occupational exposure'*

#### ICRP recommendations

The ICRP definition of occupational exposure of workers includes all exposure to ionising radiation that workers may experience while performing their duties and during their presence at the workplace that may be caused by sources the employer controls and is responsible for.[4] No account will be taken of exposure not related to duties or presence in the workplace, such as medical exposure as a patient and the exposure workers – like any other person – may experience due to radiation in the environment, whether from natural sources or otherwise.

#### European directive

The European directive[7] that the Decree on Radiation Protection is based upon does not contain a definition of 'occupational exposure', but does differentiate between 'exposed workers' and 'members of the public'. Exposed workers are defined as follows:

> Exposed workers: persons, working either self-employed or working for an employer, subject to an exposure incurred at work from practices covered by this Directive and liable to result in doses exceeding one or other of the dose levels equal to the dose limits for members of the public.

#### Regulations in the Netherlands

The Decree on Radiation Protection differentiates between members of the public, workers and exposed workers. The definition of the latter category, defined in Article 1 of the Decree, is consistent with the definition in the European Decree (see also 1.3 and Annex C):

> Exposed worker: a worker* who is exposed during working hours and as a consequence of certain activities, which may lead to a dose that is higher than one of the dose limits listed in Article 76 of exposure for members of the public.

The definitions of occupational exposure in the Decree on Radiation Protection apply to all workers that may be exposed to ionising radiation while performing

* Both employees and self-employed workers; see 1.3 and Annex C.

their duties. In other words: both the group classified as ‘exposed workers’ and other workers are included. Other than guidelines for the two categories of workers, there are also guidelines for workplace measures.

### 3.1.2 *Regulations for routine personal dosimetry for workers*

When does occupational exposure require workers to wear a personal dosimeter? Certain international and national rules apply.

#### ICRP recommendations

The ICRP recommends personal dosimetry for all workers that may be exposed, unless it is clear in advance that the dose will be consistently low, and will be significantly lower than the legal limits on an annual basis. According to the ICRP, it is certainly and always necessary to systematically determine the individual dose for groups of workers among whom some members risk an effective annual dose exceeding a value to be determined between 5 and 10 mSv, unless the dose determination may be performed in a more efficient manner, as is the case for airplane crews.

Routine personal dosimetry is not considered to be necessary if all workers within a group are practically certain not to receive an effective annual dose of over 1 mSv.

For groups of workers that may expect to be exposed to more than 1 mSv per year, but less than a value to be determined between 5 and 10 mSv per year, personal dosimetry is considered desirable, but it may be organised and implemented less stringently. For these groups of workers, personal dosimetry is primarily focused on checking whether they are correctly classified as less highly exposed workers. Determining current personal doses is therefore less important.

#### European directive

The European directive prescribes a classification of exposed workers in two categories, A or B, ’for the purposes of monitoring and supervision’. This also includes the question of whether or not personal dosimetry should be applied. The basis of this classification is that someone is only considered to be an ‘exposed worker’ if an effective annual dose of over 1 mSv is considered possible.*

* Lower limits for equivalent doses for individual body parts also exist, but are only very rarely limiting in practice.

A category A worker is someone who may receive an effective annual dose of over 6 mSv, and a category B worker is someone who may expect a dose of between 1 and 6 mSv. Personal dosimetry performed by a certified dosimetry service is mandatory for category A workers. For category B workers, personal dosimetry regulations are left to the member states. The assignment for European member states is to ensure national legislation is sufficient to demonstrate that category B workers are rightfully classified as such. This provides the opportunity to make the decision of whether or not to perform personal dosimetry and the way this is implemented dependent on characteristics other than worker classification alone.

### Regulations in other countries

In other countries, the need and requirement for personal dosimetry is often related to the workplaces' radiological classification. The European directive also provides room for this interpretation. This approach is also reflected in the guidance documents of the International Atomic Energy Agency (IAEA)[10]:

> Individual monitoring is normally required for persons who routinely work in areas that are designated as controlled areas because of the external radiation hazard. An individual monitoring programme for external radiation exposure is intended to provide information for the optimisation of protection, to demonstrate that the worker's exposure has not exceeded any dose limit or the level anticipated for the given activities, and to verify the adequacy of workplace monitoring. For supervised areas where individual monitoring is not required, it may be simpler to use a limited number of individual dosimeters than to adopt a comprehensive programme of monitoring of the workplace. In any case, individual monitoring for the purpose of dose records may be considered good practice for all workers in a supervised area.
>
> It may be appropriate to derive an assessment of exposure from the results of workplace monitoring when:
>
> a No effective method of individual monitoring is available and a method based on workplace monitoring has been shown to be acceptable;
> b Doses are relatively constant and can be reliably assessed by other means; or
> c The workers concerned are regularly employed in a supervised area, or only occasionally enter controlled areas

An overview of personal dosimetry regulation in various countries is provided in Annex D.

### Regulations in the Netherlands

Finally, the situation in the Netherlands. Within our legal framework, so according to the Decree on Radiation Protection, which is based on the European directive, classification as ‘exposed worker’ – regardless of further differentiation as category A or B worker as also defined in the Decree on Radiation Protection – means that routine personal dosimetry and registration of personal data are mandatory (Articles 87 and 90, see Annex C). Registration primarily entails keeping records of personal details relevant to personal radiation protection efforts.

## *3.1.3 Practical implementation*

This concludes the overview of regulations regarding the selection of workers eligible for personal dosimetry. How these regulations are implemented in daily practice in the Netherlands is described below.

### 1984 Health Council Advisory Report

In the Netherlands, a commonly used worker categorisation is based on a Health Council advisory report dating from 1984.[6] At the time, the Council proposed classification ‘based on the criteria of whether the likelihood exists that the reference level that is numerically 1/10$^{th}$ of the annual dose limits for occupational exposure will be exceeded’. This reference level was therefore numerically equivalent to the annual limit for the general public valid at that time and proposed in the advisory report. The Council defined the following categories:

Category A: individuals who on account of their occupation or training are exposed to radiation, and carry a reasonable risk of receiving an annual radiation dose in excess of 3/10$^{ths}$ of the annual dose limits for occupational exposure.

Category B: individuals who on account of their occupation or training are exposed to radiation, and carry a reasonable risk of receiving an annual radiation dose in excess of 3/100$^{ths}$ but generally less than 3/10$^{ths}$ of the annual dose limits for occupational exposure.

If desired, category B workers can be further differentiated into:

Individuals in category B that carry a reasonable risk of receiving an annual radiation dose greater than 1/10$^{th}$ of the annual dose limits for occupational exposure (category B1).

Individuals in category B for whom the annual radiation dose is generally less than 1/10th of the annual dose limits for occupational exposure (category B2).

The distinction between categories B1 and B2 allows for greater opportunities to customise radiation protection than if this distinction is not made. What this means for worker selection in daily practice depends on:

- the application of the ALARA principle to radiation protection in the workplace;
- ensuring required information, instruction, training and support is provided;
- facilities for personal dose control and dose registration;
- limitation of personal doses.

In 1984, annual dose limits were 50 mSv for occupational exposure and 5 mSv for exposure of the general public. The division into three categories corresponded to the following exposure levels:

- category A workers: 15 - 50 mSv per year;
- category B1 workers: 5 -15 mSv per year;
- category B2 workers: 1.5 -5 mSv per year.

It should be noted that occupational exposure is by definition always additional exposure, as workers may also be exposed to radiation outside of the workplace as members of the public, albeit up to the maximum annual dose limit for members of the public.

In its 1984 advisory report, the Council called for all exposed workers, whether category A, B1 or B2, to be equipped with personal dosimeters.

### Implementation using current exposure limits

Exposure limits have since been adjusted. The Decree on Radiation Protection outlines annual limits for various dose quantities.

For ‘exposed workers’, the limit for the effective annual dose is set at 20 mSv. In practice, this limit applies to category A workers. Based on the classification criteria, a dose constraint of 6 mSv applies for category B workers.*

Other workers may receive an effective annual dose of up to 1 mSv.

* A dose constraint differs from a dose limit. It is a preset ceiling value for the dose, set as part of the optimalisation process of radiation protection. Exceeding a dose constraint may lead to reconsideration of ALARA measures and possibly revision of the classification in category A or B.

Application of the classification criteria from the 1984 Health Council advisory report to the current exposure limit of 20 mSv for ‘exposed workers’ results in the following subdivision:

- category A workers: 6 -20 mSv per year;
- category B1 workers: 2 -6 mSv per year;
- category B2 workers: 0.6 -2 mSv per year.

This means that under current limits, category B2 workers may be exposed to radiation levels that are partly over and partly below the 1 mSv limit for other workers, and so do not automatically all fall into the category ‘exposed workers’. The classification from the 1984 advisory report therefore does not match with the regulations outlined in the Decree on Radiation Protection. The Committee does, however, endorse the approach from the 1984 advisory report, and makes suggestions suited to the current situation.

### *3.1.4 Assessment of recent changes in radiation protection practice*

The policy for wearing personal dosimeters has not changed as a consequence of the modified limits. The basis remains that all ‘exposed workers’ must wear a personal dosimeter.

However, changes have since occurred in daily practice. In the Netherlands, past practice has been to classify every worker working with or in the vicinity of sources of ionising radiation as an ‘exposed worker’, and to provide them with individual personal dosimeters. However, based on the in itself justifiable intention not to unnecessarily fulfil the requirement for routine personal dosimetry, an increasing number of institutions have a tendency to no longer classify certain workers, individually or collectively, as ‘exposed workers’, and no longer require them to wear a personal dosimeter. Legally this is possible if it can be demonstrated that the exposure of the workers in question is so low that they need not be considered ‘exposed workers’.

## 3.2 Health concerns

Legally, certain groups of workers who have traditionally worn personal dosimeters may be exempt from doing so. But is this safe in terms of health? If so, on what conditions?

### 3.2.1 *Decreasing the number of workers with personal dosimeters*

The Committee feels that also in terms of health it is possible to stop using routine personal dosimetry to monitor workers who do work in an environment where radiation may occur, but for whom exposure in practice is consistently low and less than 1 mSv per year. This applies to those groups for which a risk inventory and evaluation (RI&E) has shown that:

- the level of exposure, including reasonably predictable malfunctions is generally consistently low; the Committee proposes to set this level at less than 0.2 mSv per quarter, so that the total annual dose will remain well below the annual dose limit for other workers; and also
- the odds of abnormal events leading to potentially significantly higher exposure is minimal. In this context, the Committee recommends defining 'significantly higher exposure' as exposure of more than 1/5$^{th}$ of the annual dose limit for other workers, or 0.2 mSv per event.

### 3.2.2 *Ensure radiation protection*

However, in accordance with previous Health Council advisory reports[3,6,11] and ICRP recommendations, the Committee does feel that the basic principle of radiation protection must be that everyone who may be exposed to ionising radiation in the workplace is entitled to suitable personal radiological protective measures. Therefore, it concludes that workers that do not or are no longer required to routinely wear personal dosimeters but who do work in an environment where they may be exposed to ionising radiation are still in need of a form of radiation protection, even if they are not considered to be 'exposed workers' using the definition outlined in the Decree on Radiation Protection.

An undesirable consequence of no longer considering groups of workers as 'exposed workers' is that less protection is provided than the Committee recommends for occupational exposure in general. For example, individual data relevant for the periodic evaluation of tasks and working conditions in the context of applying the ALARA principle is no longer recorded for these groups. The Committee therefore considers it desirable that a number of additional measures are taken.

### Include new category of workers in the guidelines

The Committee recommends creating a new category within the other workers: category C. This category includes workers that are not classified as ‘exposed workers’ (and therefore are exempt from routine personal dosimetry) but who do work with equipment or substances that emit ionising radiation and therefore run a risk of exposure. The Committee hereby upholds the intentions of the recommendations made in the 1984 advisory report.

### Setting up monitoring for this group

In practice, a large proportion of these workers will in part have duties in monitored or controlled zones. While their annual exposure will be so low that they are not considered ‘exposed workers’, they do risk a not insignificant dose of radiation in the event of a calamity or major incident. Therefore, exposure for this group of workers must be monitored using the workplace monitoring systems for controlled and supervised zones outlined in Articles 84 and 85 of the Decree on Radiation Protection (see Annex C). This monitoring must be part of a programme for radiation protection or a safety management system, and must be adequate for:

- evaluating and testing measures and facilities for worker radiation protection within the application of the ALARA principle;
- verifying that the criteria for classification as category C workers are met;
- reliable dose determination in the event of abnormal situations or a radiological accident.

### Radiation protection programme for potential occupational exposure

This radiological protection programme must be performed or supervised by a radiation protection expert, meaning a recognized expert in the field of radiation protection. In the advisory report ‘Education and training of radiation protection experts’ that is published simultanuously with this report, the Committee makes proposals for modification of the system of education in radiological protection.[12]

Registration requirements should be defined for category C workers, allowing concrete goals to be set for these workers as well. These regulations will formalise and secure the protection of this group of workers, while at the same time doing justice to the employer’s own responsibilities.

Chapter 4

# Requirements for a good risk analysis

A good level of radiation protection is entirely dependent on an adequate risk analysis as this is the basis for assigning workers to a certain category. What requirements must such a risk analysis fulfil?

## 4.1 Risk analysis objective

According to the Decree on Radiation Protection (Article 10, see Annex C), the risks of actions during which exposure to ionising radiation may occur must be identified and evaluated ‘by or under supervision of an expert’. Insofar as worker protection is concerned, expert findings are recorded in a risk inventory and evaluation (RI&E) as defined in Article 5 of the Working Conditions Act of 1998.*

An RI&E must be performed in which the odds of exposure and expected doses are recorded, among other things. Based on the outcomes, classification as ‘exposed worker’ and categorisation into A and B workers or other worker takes place (and, if the recommendation from the previous chapter is followed, as category C worker).

* Extensive information on RI&Es is available at www.rie.nl.

## 4.2 Quality assurance

While the Committee does not consider it the Health Council's task to formulate detailed quality criteria, it does provide requirements regarding the intent and quality of the radiological risk analysis that should be part of the RI&E.

The RI&E should provide insight into the degree of personal exposure workers may experience as a result of their work. An RI&E is not set up for individual workers, but applies to groups with common characteristics in terms of tasks and activities. All contributions to the personal dose due to the presence and use of sources of radiation within the company in question must be taken into account. When determining the odds and degree of potential exposure, all measures taken to limit exposure in daily practice as much as reasonably possible and to prevent accidents must be taken into account. Whether workers themselves are actively involved in any radiological activities is not relevant here.* The personal dose received due to reasons unrelated to work is also not considered.

In addition to the dose to be expected under normal working and operating conditions (including any reasonably to be expected malfunctions) the odds of incidents and the likelihood workers will be exposed to radiation in the event of such incidents must be considered separately.

If a safety management system is present or being developed, the RI&E must be a part of it.

In order to achieve these objectives, an RI&E must meet the following requirements:

- a qualified radiation expert is responsible for its formulation;
- it has to be indicated which sources of ionising radiation are used in the company, and which (groups of) workers can and may be exposed; in this case, all workers in question must at least be classified as category C workers;
- it must be indicated for which (groups of) workers there is a reasonable chance that the annual dose limit of 1 mSv is exceeded, and they should therefore be considered 'exposed workers';
- for 'exposed workers' the extent to which they can and may be exposed has to be estimated and the classification into category A and B workers has to be indicated;
- it has to be indicated which groups of other workers can and may be exposed such as to be classified as category C workers.

* As defined in the Decree on Radiation Protection as 'activities with sources of radiation' and 'work with natural sources'.

As clarification of the phrasing ‘can and may be exposed’, the Committee notes that not only the estimate of ‘can’ in terms of odds or probability is relevant when drafting an RI&E. It also has to be considered whether there is a valid reason for exposure. In this case ‘can’ is considered as ‘is allowed to’. In other words: is possible exposure reasonable within the profession or tasks performed. If this is not the case, exposure is not permissible.

Chapter 5

# Conclusion

## Radiological protection care is necessary

Working with or in the vicinity of equipment or substances that emit ionising radiation may have adverse health effects. Therefore, adequate radiological protection care is desirable for the workers involved. To safeguard a high degree of protection, this care must be tailored to suit specific needs.

## Personal dosimetry is important for protecting workers

Wearing personal dosimeters plays a key role in protecting workers. Measuring actual exposure is an important element in the overall package of measures to protect people from the adverse effects of exposure to radiation in the workplace. For example, this makes it possible to check whether legal requirements for maximum allowed radiation doses are met and whether exposure is kept as low as can reasonably be achieved.

## Abandoning personal dosimetry is allowable for certain workers

To date, it was common practice in the Netherlands to fit practically all workers in workplaces containing equipment or substances that emit radiation with a personal dosimeter, even if their exposure was lower than the annual dose limit

applicable for workers in general. In principle, this policy may be changed so that these workers are no longer considered ‘exposed workers’. There are no legal or health objections standing in the way of this.

### A new category of workers is desirable

In order to safely decrease the number of workers with personal dosimeters, a number of conditions must be met. Categorising them as other workers currently means that no specific measures focused on controlling individual exposure are necessary. The Committee feels this is undesirable, because these workers do work in an area where exposure to ionising radiation is possible. Therefore, it recommends establishing a new category of workers within the group of other workers, the category C workers. Routine personal dosimetry is not required for this category, but a number of other measures are, such as registration and monitoring exposure through other methods.

### A good risk analysis contributes to good protection

An adequate risk analysis is important to ensure that workers are assigned to the correct category. The Committee has outlined a number of concrete requirements for this analysis, such as the involvement of a radiation protection expert.

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# Annexes

Annex **A**

# Request for advice

On 13 April 2005, the State Secretary of Social Affairs and Employment sent the Health Council the following letter (reference ARBO/M&A/2005/24261):

Dear Mr Knottnerus,

I request your attention for the following:

For dozens of years, exposure of workers in the Netherlands to ionising radiation has been monitored using personal dose control tools. This routine monitoring is done based on the Decree on Radiation Protection, which states that workers who are exposed to ionising radiation due to their occupation that may lead to a dose of over one millisievert per year (so-called exposed workers) must be provided with suitable, personal dose control tools.

Within the sectors in the Netherlands where ionising radiation is an issue, there has been broad consensus for many years on the interpretation of the phrase "…that may lead to…" in said regulation; everyone who comes into contact with a relevant amount of radioactive substances or with equipment that produces ionising radiation in the course of performing their duties wears a personal dose control tool. The Occupational Health and Safety Inspectorate enforces the regulations on dose monitoring according to this consensus.

Recently, based on their risk analysis of ionising radiation, a medical institution decided to no longer to consider certain occupational groups within its organisation as exposed workers and therefore to

no longer provide them with personal dose control tools. This is a new viewpoint within the medical sector. The question is whether this can be considered ‘the current state of technology or science’ regarding the radiological protection of workers, that may be implemented in other healthcare institutions as well.

Given this development, I would appreciate your advice on the following issues:

- What is the importance of personal dosimetry within radiation protection?
- How can Dutch and European legal requirements regarding routine personal dosimetry be implemented in practice? How can the phrase “…that may lead to…” be clarified or defined more specifically? What is the ‘current state of science’ on this issue?
- The risk analysis required by the Decree on Radiation Protection is the basis for allowing employers to decide whether or not to define certain occupational groups as exposed worker. What criteria must such a risk analysis meet, if the quality is to be assured and its applicability is to remain general and tenable?
- Can the number of workers for whom routine personal dosimetry is performed be decreased in a sensible manner based on current scientific understanding? If so, on what conditions? To what degree is it still necessary to monitor received radiation doses, for example with the aid of other monitoring methods, in the event of calamities or incidents?

Given the current relevance of the issue, I would ask that you deliver an advisory report within as short a term as possible, so that the current state of science in the field becomes clear and employers can take their responsibilities regarding risk analyses and the consequences thereof in a sound way. This state of technology will also be of importance in determining the Occupational Health and Safety Inspectorate’s supervision of the regulations in question.

Yours sincerely,
The State Secretary of Social Affairs and Employment,
(signed.) (H.A.L. van Hoof)

Annex **B**

# The Committee

This advisory report was written by the Standing Committee on Radiation and Health, consisting of:

- Professor M. de Visser, *chairperson*
  Vice-President of the Health Council of the Netherlands, The Hague
  Professor of neuromuscular diseases, University of Amsterdam
- Dr. L.M. van Aernsbergen, *advisor*
- Physicist, Ministry of Housing, Spatial Planning and the Environment, The Hague
- Professor J.J. Broerse
  Professor emeritus of medical radiation physics, Leiden University Medical Centre
- Dr. F.R. de Gruijl
  Biophysicist, Leiden University Medical Centre
- Professor M.G.M. Hunink
  Professor of clinical epidemiology and biostatistics, Erasmus MC Rotterdam
- Chr.J. Huyskens
  Radiation physicist, Eindhoven University of Technology
- Dr. A. Keverling Buisman, *advisor*
  Physicist, Schoorl
- Professor A.J. van der Kogel
  Professor of radiobiology, University Medical Centre Nijmegen St Radboud

- Professor J.J.W. Lagendijk
  Professor of clinical physics, University Medical Centre Utrecht
- Professor J.W. Leer
  Professor of radiotherapy, University Medical Centre Nijmegen St Radboud
- Professor P.H.M. Lohman
  Professor emeritus of radiation genetics and chemical mutagenesis, Leiden University
- L.W. Meinders, *advisor*
  Netherlands Health Care Inspectorate, Ministry of Health, Welfare and Sport, The Hague
- Professor D. van Norren
  Professor of ophthalmic physics, Utrecht University
- Professor W.F. Passchier
  Professor of risk analysis, Maastricht University
- Professor T.J.F. Savelkoul
  Professor of medical toxicology and radiation hygiene, Leiden University Medical Centre
- A.M.T.I. Vermeulen, *advisor*
  Ministry of Social Affairs and Employment, The Hague
- Professor L. Verschaeve
  Professor of toxicology, University of Antwerp, Belgium
- Professor A. Vander Vorst
  Emeritus professor of electrical engineering, Louvain la Neuve, Belgium
- Professor A.A. van Zeeland
  Professor of molecular radiation dosimetry and radiation mutagenesis, Leiden University
- Dr. E. van Rongen, *secretary*
  Radiobiologist, Health Council of the Netherlands, The Hague

### The Health Council and interests

Members of Health Council Committees are appointed in a personal capacity because of their special expertise in the matters to be addressed. Nonetheless, it is precisely because of this expertise that they may also have interests. This in itself does not necessarily present an obstacle for membership of a Health Council Committee. Transparency regarding possible conflicts of interest is nonetheless important, both for the President and members of a Committee and for the President of the Health Council. On being invited to join a Committee, members

are asked to submit a form detailing the functions they hold and any other material and immaterial interests which could be relevant for the Committee's work. It is the responsibility of the President of the Health Council to assess whether the interests indicated constitute grounds for non-appointment. An advisorship will then sometimes make it possible to exploit the expertise of the specialist involved. During the establishment meeting the declarations issued are discussed, so that all members of the Committee are aware of each other's possible interests.

Annex **C**

# Decree on Radiation Protection

This annex includes a number of extracts from the Decree on Radiation Protection relevant to this advisory report.

## Definitions of dose quantities, as included in Appendix 2

The effective dose, E, is the sum of the weighted equivalent doses in all tissues and organs listed in table 2.2, as a consequence of internal and external radiation […] The unit of effective dose is J $kg^{-1}$, specifically known as sievert (Sv).

The equivalent dose, $H_T$, in a tissue or organ T is the sum of the products of the average absorbed dose $D_{TR}$, in a tissue or organ T due to radiation R and the radiation weighting coefficient $w_R$ […] The unit of effective dose is J $kg^{-1}$, specifically known as sievert (Sv).

A number of articles cited below mention limit values for effective and equivalent doses. For clarity, only the limit values for the effective dose are quoted.

## The ALARA requirement

Article 5

**1.** The employer ensures that the effective or equivalent doses resulting from an action for individual persons, in relation to the number of exposed persons, is as low as reasonably achievable.

**2.** Regarding potential exposures, the employer ensures that both the dose in the event of exposure and the odds of exposure are as low as reasonably achievable.

## Definitions of workers, as included in article 1

*Worker*: individual who, either as employee of or under supervision of an employer, or independently, performs work;

*Exposed worker*: worker who is exposed during working hours as a consequence of his duties, which may lead to a dose that is higher than the dose limits mentioned in article 76.

Article 76
**1.** The employer ensures that the following doses for workers due to duties performed under his responsibility are not exceeded:
a. an effective dose of 1 mSv per calendar year, […]

Article 77
**1.** The employer ensures that the following doses for exposed workers due to duties performed under his responsibility are not exceeded:
a. an effective dose of 20 mSv per calendar year, […]

## Differentiation between A and B workers, as included in article 1

*A worker*: the exposed worker as defined in Article 79, second paragraph.
*B worker*: exposed worker other than an A worker.

Article 79
**1.** The employer categorises exposed workers as A or B workers for the purposes of monitoring and supervision.
**2.** An A worker is an exposed worker who may receive an effective dose greater than 6 mSv in one calendar year, or an equivalent dose larger that three tenths of the dose limits listed in Article 77.

## Measurement and registration of exposure

Article 87
**1.** The employer provides the exposed worker with a suitable, personal dose control tool, which is obtained by the employer from a dosimetric service as defined in Article 8.
[…]

Article 90
The employer ensures the following is individually registered for each worker:
a. name, date of birth and gender
b. classification in category A or B
c. measured or determined doses based on Articles 87 through 89
[…]

## Workplaces and workplace monitoring

Article 83
1. The employer ensures that, if necessary for the purposes of protection against ionising radiation:
a. A workplace is considered a controlled zone if:
1°. the dose a worker may potentially receive is equal to an effective dose higher than 6 mSv in a calendar year or an equivalent dose higher than three tenths of the dose listed in Article 77, paragraph one, under b, or
2°. a possibility of dissemination of radioactive substances from the workplace exists, such that persons may receive a dose higher than an effective or equivalent dose, listed in Article 76.

b. a workplace is considered supervised if the potential effective dose a worker may receive is greater than 1 mSv per calendar year and less than 6 mSv per calendar year or the equivalent dose is higher than the dose listed in Article 76, under b, and lower than that listed under a, first item.
[…]

Article 84
1. Regarding a controlled zone, the employer ensures that:
a. the zone is demarcated and access is limited to the people he indicates, and that the zone is monitored in agreement with the procedures defined by him;
b. measures have been taken for those eventualities that entail a significant risk of spreading of radioactive substances; these measures include access to and departure from the zone by persons or goods.
c. taking into account the nature of the sources present and actions involved, a workplace monitoring system is in place;
[…]

Article 85
1. Regarding a controlled zone, the employer ensures that:
a. taking into account the nature of the sources present and actions involved, a workplace monitoring system is in place;
[…]

## Determining the risks

Article 10

**1.** The employer ensures that at least the following takes place, performed by or under supervision of an expert, with a view to protection against ionising radiation:

a. plans for actions are critically examined prior to performance thereof, the risks are identified and evaluated, and permission is granted before performing the action. […]

[…]

**3.** Insofar as exposed worker protection is concerned, expert findings are recorded in a risk inventory and evaluation as defined in Article 5 of the Working Conditions Act of 1998.

Annex **D**

# Comparison of personal dosimetry regulations

| | |
|---|---|
| *EU directive* | Category A: mandatory<br>Category B: not mandatory; if necessary to the degree required to demonstrate categorisation is correct |
| *The Netherlands* | Category A: mandatory<br>Category B: mandatory, exemption is possible |
| *Sweden* | Category A: mandatory; advisory list for activities in category A<br>Category B: not mandatory |
| *Belgium*<br>*Germany* | Category A: mandatory<br>Category B: mandatory<br>Mandatory in controlled zone |
| *Great Britain* | Mandatory for classified workers (equivalent to Category A)<br>Non-classified workers: not mandatory, if necessary to the degree required to demonstrate classification of workers is not necessary<br>Mandatory in controlled zone |
| *France*<br>*Switzerland* | Mandatory when working in *zone contrôlée* and *zone surveillée* |

| | |
|---|---|
| *United States Federal NRC & state regulations* | Mandatory for:<br>• Workers that are likely to potentially receive an effective dose of over 5 mSv<br>• Individuals entering a room with high radiation levels<br>• Women who have indicated they are pregnant and who are likely to potentially receive an effective dose of over 1 mSv<br>• Workers who work with medical fluoroscopy equipment |
| *United States Department of Energy* | Mandatory for workers that are likely to potentially receive an effective dose of over 1 mSv |
| *IAEA safety standards* | Mandatory in controlled areas<br>Not required in supervised areas |