CENTRE D'ETUDE SUR L'EVALUATION
DE LA PROTECTION DANS LE DOMAINE NUCLEAIRE

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SURVEY OF INTERNATIONAL RULES AND PRACTICES REGARDING DELINEATION OF AND ACCESS TO REGULATED AREAS FOR RADIATION PROTECTION

- FINAL REPORT –

ANNEXES

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COUNTRY SHEET - BELGIUM

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1. INTRODUCTION

The Belgian regulations on the designation of regulated radiation areas are based on the Royal Order of 20 July 2001 on general regulations for protection of the population, workers and the environment against the danger of ionising radiation [1]. This order is applicable to all sectors of activity.

The description of the practical implementation of regulated radiation areas designation in the nuclear industry and research sector is supplemented with information provided by the Doel nuclear power plant (radiation protection procedure [2] and discussions with the site radiation protection manager) and with the worksite rules of the SCK-CEN research centre [3].

Additional information on medical and veterinary aspects was obtained from Conseil Supérieur d'Hygiène (CSH) report no. 7221 on quality assurance and radiation protection in nuclear medicine, published in December 2003 [4], the guide to the use of X-rays for medical purposes [5] and the guide to good practice in the use of X-rays in veterinary medicine [6].

All these regulations and guides are published in French. The quotation from the original texts presented below in insert and italic text are translated into English for a better reading of the report. Please refer to the official original texts if necessary.

2. DESIGNATION OF REGULATED RADIATION AREAS IN THE GENERAL REGULATIONS

2.1. Purpose and principle

The Belgian regulations on protection against ionising radiation state that the various types of practice involving exposure to ionising radiation must be justified by the advantages that they procure. Any exposure, whether it involves members of the public, apprentices, students or persons exposed occupationally, must be limited to a level as low as reasonably achievable, taking economic and social factors into consideration.

In the definition of a controlled area, it is stipulated that the area must be set up with the aim of protection against ionising radiation and containment of radioactive contamination, and that access to it must be controlled.

Chap. 1: General provisions – Definitions

controlled area: area subject to specific regulations for protection against ionising radiation and containment of radioactive contamination, access to which is regulated; in establishments authorised according to the provisions of these regulations, any area in which three-tenths of the annual dose limits defined for occupationally-exposed persons are likely to be exceeded shall form a controlled area or be included in one;

supervised area: area subject to appropriate monitoring for protection against ionising radiation; in establishments authorised according to the provisions of these regulations, any area in which a person may be subjected to an exposure likely to result in doses greater than any of the dose limits defined for members of the public and which is not considered to be a controlled area shall form a supervised area or be included in one.

2.2. Types of facility covered by the regulations

The Royal Order of 20 July 2001 refers to all sources of ionising radiation and to all sectors of activity.

2.3. Assessment of the nature and magnitude of the risk before designation

The facility operator is required to establish a radiation protection service, one of the tasks of which is to delineate and mark out the controlled areas. Although job studies are not mentioned explicitly, this service is also tasked with assessing "the intensity of the radiation" and the nature of the radiation, as well as determining radioactive contaminations and their characteristics.

The checks and assessments conducted by the radiation protection service must be recorded in registers.

Royal Order 20/07/01 – Chapter III General Protection – Section II Physical and medical monitoring

Article 23 Physical monitoring
23.1. The facility operator, and by default the company owner, is required to organise a physical monitoring service tasked with, in general, the organisation and monitoring of the measures necessary to ensure compliance with the provisions of these regulations and of the orders and decisions of the Agency implementing these regulations, concerning occupational health and safety, and the security and public health of the neighbourhood, excluding the provisions restricted to medical monitoring.
This monitoring includes:
1. delineation and marking of controlled areas;
2. inspection and monitoring of existing protection systems and means;
3. proposal of supplementary protection means and appropriate procedures that this service judges necessary; it shall take into account the principle of optimisation covered in article 20.1.1.1;
(...)
10. the following determinations:
a) determination of the intensity of the radiation and identification of the nature of the radiations in the locations concerned;
b) determination of radioactive contaminations, the nature of the contaminant radioactive substances, their activity, their concentrations per unit volume and area, their physical state and, if possible, their chemical state;
c) determination, in consultation with the accredited medical practitioner responsible for medical monitoring of workers, including external workers:
– of individual doses, including doses resulting from internal exposure and doses due to accidental exposure, to planned special exposure and to emergency exposure;
– of radioactive contamination of persons entailing decontamination measures with medical intervention;

23.2. The observations and determinations by the physical monitoring service are recorded either in registers with numbered pages or on numbered sheets collected in bundles. However, those defined in item 10° c) of article 23.1 are communicated directly to the service responsible for medical monitoring. This transmission is immediate in emergencies. The registers and bundles are retained for thirty years at the head office of the company. If the business is wound up, the company transmits these documents to the Agency.

2.4. Area types

The Belgian regulations refer to two types of area: controlled areas and supervised areas.

- **Controlled area:** Area subject to specific regulations for protection against ionising radiation and containment of radioactive contamination, access to which is regulated. A controlled area is an area in which three-tenths of the annual dose limits defined for occupationally-exposed persons are likely to be exceeded.

- **Supervised area:** Area in which a person may be subjected to an exposure likely to result in doses greater than any of the dose limits defined for members of the public and which is not considered to be a controlled area.

With regard to marking of the areas, mention is also made of division of a controlled area according to the dose rate. Three areas are defined:

- dose rate > 1 mSv/h: a sign "Very high radiation intensity" must be posted
- dose rate > 0.2 mSv/h: a sign "High radiation intensity" must be posted
- dose rate > 20 µSv/h: a sign "Ionising radiation" must be posted.

Royal Order 20/07/01 Chap. I General provisions - Article 2 Definitions

Controlled area
Area subject to specific regulations for protection against ionising radiation and containment of radioactive contamination, access to which is regulated; in establishments authorised according to the provisions of these regulations, any area in which three-tenths of the annual dose limits defined for occupationally-exposed persons are likely to be exceeded shall form a controlled area or be included in one;

Supervised area
Area subject to appropriate monitoring for protection against ionising radiation; in establishments authorised according to the provisions of these regulations, any area in which a person may be subjected to an exposure likely to result in doses greater than any of the dose limits defined for members of the public and which is not considered to be a controlled area shall form a supervised area or be included in one;

Royal Order 20/07/01 Chapter III General Protection - Section I Basic standards for protection against exposure to ionising radiation - Article 20 Dose limitation

20.1.3. Dose limits for occupationally-exposed persons
The effective dose limit for occupationally-exposed persons is defined as 20 millisieverts per rolling 12-consecutive-month period.
Subject to compliance with this dose limit, the equivalent dose limit for each individual organ or tissue is defined as 500 mSv per rolling 12-consecutive-month period.
- *The equivalent dose limit for the eye lens is defined as 150 mSv per 12 consecutive months.*
- *The equivalent dose limit for the skin is defined as 50 mSv per year averaged over any 1 cm^2 area of skin, whatever the exposed area.*
- *The equivalent dose limit for the hands, forearms, feet and ankles is defined as 500 mSv per rolling 12-consecutive-month period."*

20.1.4 Dose limits for members of the public
Without prejudice to the provisions of article 20.1.2, the following dose limits shall be complied with for members of the public:
a) the effective dose limit for members of the public is defined as 1 millisievert per year;
b) subject to compliance with the limit defined in a) hereinabove:
- *the equivalent dose limit for the eye lens is 15 millisieverts per year;*
- *the equivalent dose limit for the skin is defined as 50 millisieverts per year averaged over any 1 cm^2 area of skin, whatever the exposed area.*

Royal Order 20/07/01 Chapter III General Protection – Section III General protection systems and procedures – Article 31 Warning signs, symbols and texts
***31.3** All the additional information intended to warn exposed persons about the dangers that they might risk shall be written visibly and legibly under the warning sign. The following texts are used:*
- *'Very high radiation intensity': when the dose likely to be delivered to individuals exceeds 1 mSv/h. When this text is posted on the access door to a room, it is accompanied by an audible and/or visual signal unless access is possible only with permission from an empowered person or under monitoring by the physical monitoring service. These signals operate continuously or are activated when a person opens the access door to the room or enters the room.*
- *'High radiation intensity': when the dose likely to be delivered to individuals usually exceeds 0.2 mSv per hour.*
- *'Ionising radiation': when the dose likely to be delivered to individuals usually exceeds 20 µSv per hour.*
- *'Danger of radioactive contamination': when unsealed sources are stored or used.*

2.5. Area boundary characteristics

The Royal Order does not specifically state what form the separations between controlled areas, supervised areas and the rest of the establishment must take.

It stipulates only that, in the case of a contamination risk in certain types of establishment (including the nuclear industry and the medical sector), a blank wall or a clear space must separate the supervised or controlled areas from certain rooms such as canteens and conference rooms.

In addition, the article (52.2) concerning medical premises stipulates that, outside rooms using sources of ionising radiation, the dose received at any accessible location where persons might stay must not exceed 0.02 mSv per week. Furthermore, hospital rooms for patients with radioactive sources must be designed to comply with a dose constraint in neighbouring rooms of 0.5 mSv per person and per year (taking occupancy into account). Lastly, the rooms must be lockable.

Royal Order 20/07/01 Chapter III General Protection – Section III General protection systems and procedures – Article 29 Room protection
29.4. To reduce contamination risks, controlled or supervised areas in which unsealed sources are used in a class I or class II establishment shall be separated by a blank wall or a clear space from the following premises:
a) conference rooms, classrooms and theatres;
b) canteens, kitchens and other places where foodstuffs are kept, stored and/or consumed;
c) any room used for an activity that is not essential, at that location, to the operation and use of the class I or class II establishment in question.
If communication is nevertheless necessary between these two types of premises, it shall provide security against the contamination risk at least equivalent to that provided by a clear space.

Royal Order 20/07/01 Chapter VI Application of ionising radiation in human and veterinary medicine - Article 52 General provisions for establishments and premises

Art. 52.2. Premises
Without prejudice to the provisions of chapter III, the premises where the ionising radiation sources and the radiological facilities discussed in article 50.2 are held or used must satisfy the following conditions:
1. at the external surface of the rooms, at any accessible location where persons may stay, the received dose must be less than 0.02 millisievert per week, under the usual conditions of operation of the facilities;

2. the rooms shall have key-operated locks; however, exit from the rooms shall be possible at any time;

3. with the exception of dental practices where an apparatus designed specifically for dental radiography is located, the radioactivity symbol and the texts stipulated in article 31 must be posted on the doors;

4. the members of the personnel, and any person in the vicinity of the user, must be protected by means of the systems and procedures described in chapter III, section III. Personal protective equipment must be available in the premises where the sources and facilities are held and used. The necessary measures must be taken to avoid any unnecessary exposure of the patient, in accordance with the provisions of articles 51.1 and 51.2.

The walls of hospital rooms for patients with radioactive sources shall ensure, taking room occupancy into account, compliance with a dose constraint of 0.5 millisievert per person and per year for any person not occupationally exposed working in a neighbouring room, and for any patient occupying a neighbouring room (including rooms located on the floors above and below), even in the case of exceptionally long hospitalisation.

2.6. Controlled area access conditions

Article 30 of the Royal Order, on the protection of persons in controlled areas, stipulates that any person entering a controlled area must have personal authorisation from the company owner (or his or her delegate). The names of persons entering the area must be recorded in a register, except in hospitals. The article also stipulates that personal protective equipment must be worn and that operational dosimetry must be implemented.

It should be noted that this article also includes the measures to be taken to limit the risks of dispersion of contamination (prohibition of drinking, eating, etc.; wearing of suitable personal protective equipment, etc.).

Royal Order 20/07/01 Chapter III General Protection – Section III General protection systems and procedures – Article 30 Individual protection of persons in controlled areas

30.1 Access to controlled areas
Entering into and staying in controlled areas without prior personal authorisation from the company owner or his or her delegate are prohibited. Authorisation cannot be given without organisational or work-related reasons.
The persons allowed entry to controlled areas are recorded in a register, giving their identity and, if necessary, the purpose of their visit.
The provisions of the previous paragraph are not applicable to hospitals.
Prior authorisation from the company owner shall be given to the representatives of the accredited bodies responsible for the checks stipulated in these regulations. It is not required for the personnel of the monitoring agency. The recording of these personnel in the register mentioned above cannot under any circumstances constitute an obstacle to the accomplishment of their task.

30.2 Prohibitions
Persons must not drink, eat, smoke or use cosmetics when they are in a controlled area where there is a danger of contamination.
The introduction of food, drink, tobacco, handbags, handkerchiefs, cosmetics, toiletries, or utensils that can be used for drinking or eating into a controlled area is prohibited.

30.3 Personal protective equipment
Persons entering a controlled area shall wear appropriate personal protective equipment which they must leave at the exit.
Persons entering a controlled area of a class I or II establishment where unsealed sources are handled shall wear appropriate protective clothing. (…)
Work clothes and protective equipment (gloves, masks, etc.) must be checked periodically for their effectiveness and their contamination level (…) they undergo appropriate decontaminations.(…)

30.4 Controlled area monitor
The company owner appoints a monitor for each controlled area, responsible for ensuring compliance with the security measures and proper operation of the protection systems. (…)

30.5 Security measures
Any person allowed entry into a controlled area who neglects or refuses to comply with the regulatory measures, the protection requirements or the orders of the monitor shall be removed from the area. (…)

30.6. Dose measurement
The operator of an establishment subject to licensing in accordance with chapter II or subject to the regulatory requirements applicable to occupational activities in application of article 9.3 shall ensure that the dosimetry required in this article is implemented and cover its cost.
All occupationally-exposed persons shall wear a dosimeter on their chest, except in the case of exposure only to low-energy (< 200 keV) beta emitters, for which adequate monitoring must be conducted.(…)
Any visitor or worker admitted into a controlled area must wear the same dosimeters as the workers working in the area. (…)

2.7. Area marking

A trefoil radioactivity symbol must be posted at each entrance to any controlled area. As mentioned in 2.4., additional information must be given according to the dose rate of the controlled area (the article is reproduced in the same paragraph).

This information is also applicable in medical facilities (refer to article 52.2 cited in 2.5), with the exception of dental practices where there is an apparatus designed specifically for dental radiography.

Royal Order 20/07/01 Chapter III General Protection – Section III General protection systems and procedures – Article 31 Warning signs, symbols and texts

31.1. The ionising radiation warning sign, use of which is required by these regulations, corresponds to the radioactive material warning sign stipulated in the royal order of 17 June 1997 on occupational health and safety signs and its appendices.
The dimensions of the warning sign may vary according to the place or object concerned by the warning.
The proportions of the symbol, which forms part of the warning sign, must conform to those defined in the diagram below.

31.2. The warning sign shall be posted:
a) at each entrance to any controlled area;
b) on the access doors to premises where one or more radioactive substances are used, stored or held;
c) on containers containing radioactive substances;
d) on any apparatus emitting ionising radiation, except apparatus likely to result in designation of the establishments where it is held or used as class IV establishments as defined in article 3.1.d), 1, 3 and 5.

3. NUCLEAR FACILITY RULES

3.1. Types of area implemented at the Doel nuclear power plant

3.1.1. Designation according to a dose rate criterion

The Doel nuclear power plant has designated controlled and supervised areas on the basis of a dose rate criterion:

- Supervised area (white):

Area where the received dose is likely to be greater than 1 mSv per year.
In view of the definition of the controlled area, its dose rate is less than 3 µSv per hour.

- Controlled area:

The low limit of the controlled area (3 µSv/h) has been defined considering a maximum presence of 2000 h per year for a worker. Compliance with the regulations thus gives:
(3/10 x 20 mSv)/2000 h = 0.003 mSv/h.

The controlled area is then divided into 5 areas:
- white area: dose rate < 3 µSv/h (although the controlled area low limit is 3 µSv per hour, many rooms located within the controlled area have a dose rate lower than this value. They are marked in white);
- yellow area: 3 µSv/h ≤ dose rate < 20 µSv/h;
- orange area: 0.02 mSv/h ≤ dose rate < 0.2 mSv/h;
- purple area: 0.2 mSv/h ≤ dose rate < 1 mSv/h;
- red area: dose rate ≥ 1 mSv/h.

The dose rate values selected for the thresholds of each area have been defined considering the stipulations of the Royal Order concerning the marking of controlled areas (refer to 2.4.).

3.1.2. Designation according to a surface contamination criterion

A designation according to surface contamination is also applied:
- green area: surface contamination less than 0.4 Bq/cm^2 β/γ
- yellow area: surface contamination between 0.4 and 400 Bq/cm^2 β/γ
  Within this area, special provisions are applied for three zones:
  - 0.4 – 4 Bq/cm^2 β/γ
  - 4 – 40 Bq/cm^2 β/γ
  - 40 – 400 Bq/cm^2 β/γ
- red area: surface contamination greater than 400 Bq/cm^2 β/γ

3.2. Area boundary characteristics at the Doel nuclear power plant

Red areas with a dose rate between 1 and 100 mSv/h are closed by key-operated locks (keys held by the radiation protection service) and are accessible only in the presence of a radiation protection technician.

Red areas with a dose rate greater than 100 mSv/h are closed by double padlocks (one key is held by the radiation protection supervisor, the other by the control room shift supervisor).

A physical barrier must be installed when the contamination exceeds 0.4 Bq/cm^2 (or if contaminating work is planned) for each contamination area.

3.3. Area marking used at the Doel nuclear power plant

The Doel nuclear power plant applies the regulations, so the signs below are used according to the area, in addition to the trefoil of the corresponding colour:
- white area (< 3 µSv/h): “Controlled Area”
- yellow area (< 20 µSv/h): “Controlled Area”
- orange area (< 0.2 mSv/h): “Ionising radiation”
- purple area (< 1 mSv/h): “High radiation intensity”
- red area (≥ 1 mSv/h): “Very high radiation intensity”.

A “No Entry” sign is added at entrances to red areas.

Warning sign examples:

Contaminated areas, in addition to the physical barrier bearing the sign of the colour of the area according to the contamination level, are marked by a specific sign showing the type of personal protection to be worn (photograph and pictogram).

Protective clothing sign examples:

3.4. Controlled area access conditions: Mol nuclear research centre (SCK-CEN)

The SCK-CEN work site regulations include a section on general regulations on access to controlled areas, applicable to external employers. They state that, in accordance with the royal order, external workers must have passed a medical examination, must be informed of the specific aspects of work involving exposure to ionising radiation, and must have passed a training test conducted by the centre.

SCK-CEN: 4.3. art. 2:
"The royal order of 25 April 1997 obliges the employers of external contractors whose workers carry out work in the controlled areas of class I nuclear facilities (potential exposure to ionising radiation) to ensure that their workers undergo prior medical examination at the occupational health department of this establishment."
"The medical approval, which is an essential part of the access procedure, is limited to a period of six months starting from the date of the most recent blood analysis."

SCK-CEN Art. 3:
"The external workers are required to have information on the specific aspects of activities involving exposure to ionising radiation. They shall also be informed of the safety instructions" (including the personal protective means to be used).

The prior training is assessed by a test. "A result of at least 70% shall be obtained in order to have access to the technical area of SCK-CEN in order to carry out work there."

SCK-CEN Art. 4:
In the case where SCK-CEN work is carried out by third parties, only "experienced personnel who have received technical training" may perform the operations.

SCK-CEN Art. 6:
"Access to controlled areas is granted only if the external workers have first strictly followed the 'Specific instructions of the external employer'."

3.5. Specific measures to limit the contamination risk: Doel nuclear power plant

For the regulatory aspects, refer to paragraph 2.6. on access to controlled areas.

Very detailed rules on wearing personal equipment are applicable for each type of area, according to the levels of surface and/or airborne contamination (whether gloves, overshoes, gas-tight suits, etc. must be worn), along with rules on monitoring and/or assistance by the radiation protection service.

Hands must be washed between the exit scanners of first level controlled areas and second level controlled areas (equivalent to C1 and C2 portals in France).

4. RULES IN THE MEDICAL AND VETERINARY SECTOR

4.1. Area boundary characteristics

4.1.1. Outfitting of premises recommended for nuclear medicine

The guide on nuclear medicine published by the *Conseil Supérieur d'Hygiène* (CSH) [4] defines some aspects of outfitting of premises. However, it does not give any values for dose rate limits outside the rooms, just indicating where shielding is necessary.

CSH no. 7221 5.5. Equipment and premises
C. Waiting room for patients who have been injected with radioactive substances
Shielding should be used, or the premises should be laid out carefully.

CSH no. 7221 E. Storage and preparation laboratory (hot laboratory)
"This room is where the irradiation and contamination risks are highest. The sources delivered by the suppliers must be stored behind shielding or in a shielded box. They must be handled behind a shielding screen. Part of this screen must be transparent (e.g. lead glass). To avoid irradiation of the lower body, the horizontal surface of the table must also be shielded."

CSH no. 7221 F. Injection room
The injection room must be adjacent to the preparation and storage laboratory. The room must be shielded.

CSH no. 7221 G. Examination rooms
Examination room walls must be shielded.

CSH no. 7221 H. Hospital rooms (therapeutic application of radionuclides)
"A location at the end of a wing, as far away as possible from the entrance, is preferable for an area accommodating patients with sources. Rooms on upper floors avoid window shielding problems." If this is not possible, "consideration must be given to physical limitation of access to the area outside the windows". "The room walls must be shielded (concrete, lead, steel). The required thicknesses are determined by the physical monitoring service or by the approved body. Shielding of floors and ceilings must also be studied."

4.1.2. Outfitting of veterinary medicine premises

The Guide on X-rays in veterinary medicine [6] defines aspects of the outfitting of premises in which X-ray apparatus is used, mentioning the special case of CT scanners. It should be noted that the controlled area must have been "defined in agreement with the approved body".

It should also be noted that the "access doors to the controlled area must be closed before charging of the tube".

Guide to good practice – X-rays in nuclear medicine: what has to be done to install an X-ray apparatus in a nuclear medicine practice

Walls of the room in which the apparatus is installed
X-ray apparatus must be used in a room with walls providing adequate shielding against ionising radiation, in general equivalent to that provided by 1 mm of lead (for example a solid fired-clay brick about 9 cm thick is equivalent to 1 mm of lead, while plasterboard walls are insufficient). Information on lead equivalents can be obtained from the physical monitoring expert of the approved body, who can determine the necessary thickness according to the number of exposures, the characteristics of the X-ray apparatus tube and the occupancy of adjacent rooms.
The floor must also provide adequate shielding. To minimise the necessary floor thickness, the practice can be located on the ground floor or above an unoccupied cellar.
The ceiling must also have a thickness providing adequate shielding.
To minimise the necessary ceiling thickness, the practice can be located below an unoccupied attic.

Room area
Normally, the smaller the room, the more shielding is necessary.
A minimum area of 9 sq. m can be considered a reasonable compromise for a small animal radiography practice.
In equine applications, a study by the SFRP in collaboration with the IRSN has shown that a room area of 16 sq. m is appropriate.

Doors and windows
Doors and windows must have an equivalent thickness similar to that of the wall shielding. In practice, lead or lead glass linings can be added.

Special case of CT scanners
A CT scanner is considered by the regulations to be an X-ray apparatus. However, the high dose level delivered by this technique necessitates additional shielding of the operators and more room shielding than in standard radiography.

- Specific aspects of mobile apparatus

The veterinary guide [6] stipulates that "in contrast to an apparatus used in an establishment, there is no shielding barrier against radiation for mobile apparatus, and operator should take up a position as far away as possible from the radiation source. It is recommended that the apparatus be mounted on a tripod rather than held in the hand." It is also stipulated that a "work station radiation protection study should be conducted". This work station study consists in verifying that good radiation protection practices are known and implemented, imagining and anticipating any incidents and accidents, and setting up means of prevention (refer to appendix 1 for further details of the work station radiation protection study proposed by the veterinary guide to good practice). It should be noted that this work station study does not require estimation of the doses at the work station.

It is also stated that the "use of a horizontal beam mobile apparatus requires additional lead shielding and cassette holders in order to protect the operator".

4.2. Controlled area access conditions in the medical and veterinary sector

4.2.1. Personnel equipment

The CSH report states only that "Any worker admitted into a controlled area must wear the same dosimeters as the workers working in the area; this general measure must be applied to doctors on temporary contracts (self-employed medical practitioners working at the hospital)" (CSH no. 7221, 5.5 Equipment and premises)

The veterinary practical guide stipulates that personnel accessing a controlled area must wear "a chest dosimeter for the occupationally-exposed persons, radiation protection equipment and a lead apron, gloves, a thyroid shield for all personnel present during exposures and before the charging of the tube" (Guide to good practice – Safety instructions to verify before exposure). It is also stated that only "essential persons" are permitted "in the room". "If animal owners are required to be present, they must have been informed, have accepted to be present, and must be wearing personal protective equipment." Pregnant women and persons under 18 years are not admitted.

4.2.2. Required training

The guide to good practice on the use of X-rays for medical purposes (VII.2 Personnel protection) defines the obligation of information and training for students, apprentices and persons such as workers from other departments or from external contractors, who perform activities in areas presenting radiation-related risks.

The veterinary guide to good practice states that "Before entering controlled areas, veterinary surgeons must have received training on the use of X-ray apparatus and specific training on the use of radionuclides."

4.3. Specific measures for limiting the contamination risk in nuclear medicine

The recommendations of the CSH report on contamination risks cover the need for coverings and furniture that can be decontaminated in premises intended to receive patients (wards and waiting rooms) and in laboratories where radioactive products are stored.

Recommendations are also put forward for ventilation of premises at risk for contamination (recommended air inlet speed 0.5 m/s).

CSH no. 7221 I. General information
Tiling and carpeting should be excluded from administrative premises located in radioactive areas.
Furniture coverings must also be easily decontaminated, i.e. smooth and with as few joints as possible."
Premises at risk of air contamination must be ventilated and at slight negative pressure. If a laboratory is equipped with a fume hood, the air must be extracted through the hood. The ideal air inlet speed is 0.5 m/s. Air in these premises cannot be recycled; a separate ventilation system may be required. The ventilation ducts must be at negative pressure, with the fan located at the end of the line.

CSH no. 7221 5.5. C. Waiting room for patients who have received injections of radioactive substances
The floor covering of waiting rooms for patients who have received injections of radioactive substances must be easily decontaminated, as the contamination risk is non-zero.

CSH no. 7221 5.5. E.F: Storage and preparation laboratory (hot laboratory)/drug injection room
Floor and furniture coverings must be easily decontaminated.

CSH no. 7221 5.5. H. Hospital wards: Floor and furniture coverings must meet the customary decontamination criteria: smooth, without joints and extending up the walls. Refrigerating WCs or WCs with self-contained system for faeces collection.

4.4. Marking

The veterinary guide to good practice states that "a plan of the controlled area" must be posted and "the controlled area must be marked", without further defining the type of signage to be used.

5. REFERENCES

[1] 20/07/01 RGPRI Arrêté Royal du 20 juillet 2001 portant règlement général de la protection de la population, des travailleurs et de l'environnement contre le danger des rayonnements ionisants

[2] Procédure radioprotection de la centrale nucléaire de Doel, 2009

[3] Règlement de chantier SCK-CEN Ref. IDPBW.0603.N, December 2007

[4] Rapport du Conseil Supérieur d'Hygiène : Assurance de qualité et radioprotection en médecine nucléaire, December 2003 CSH no. 7221

[5] Utilisation des Rayons X à des fins médicales, AFCN, 2005

[6] Rayons X en médecine vétérinaire, AFCN, October 2010

Appendix 1. Work station radiation protection study for transportable X-ray apparatus
Guide to good practice in the use of X-rays in veterinary medicine

Parameter	Recommended	Unacceptable
Number of persons	3	< 3
Types of person	• 1 veterinary surgeon • 1 auxiliary with radiation protection training • 1 third person	• Pregnant women • Persons < 18 years
Location	• Clear area • Covered area • Brick wall in beam direction • Low light level	• Area not delineated • High light level
Controlled area marking	• Security perimeter according to the dose rate, to be estimated with the physical monitoring expert according to the kV, the number of exposures and the practice • Lighting system	• No security perimeter
Preparation of the animal	• Held by two persons • Tranquilised	• Uncontrollable
Source-animal distance and collimator	• 80 cm • Collimate	• No collimator
Protective equipment	• Apron for the persons holding the animal • Apron and thyroid guard for the person at the generator • Apron, thyroid guard and gloves for the person holding the cassette holder, the foot of the animal • Cassette holder boom	• No apron • No gloves for the person holding the cassette holder, the foot of the animal • Holding the cassette in the hand
Operator positions	• 1 m from the primary beam • The person holding the animal must not be on the side opposite the generator	• In the primary beam • Operator on the side opposite the generator

Parameter	Recommended	Unacceptable
Monitoring and prevention	• Personal dosimeter • Direct reading dosimeter with alarm • Finger dosimeter for the person holding the cassette holder • Analysis of individual dosimetric results with a view to corrective measures • Operator training	• No dosimetry
Traceability	• Recording and archiving of the examinations performed • Archiving of the dosimetric results	• No exposure inventories • No archiving of dosimetric results

COUNTRY SHEET - SPAIN

CONTENTS

1. INTRODUCTION

The Spanish regulations on the designation of regulated radiation areas are laid down in the Regulations on health protection against ionising radiation published by Royal Decree 738/2001 [1]. The regulations are applicable to all sectors of activity.

In addition to the regulations, "safety guides" have been published by the Spanish nuclear safety authority (Consejo de Securidad Nuclear – CSN). These guides cover the following 10 topics, each topic being covered by several guides:

1. Power reactors and nuclear power plants
2. Research reactors and subcritical assemblies
3. Fuel cycle facilities
4. Radiological monitoring of the environment
5. Radioactive facilities and systems
6. Transport of radioactive materials
7. Radiation protection
8. Physical protection
9. Waste management
10. Miscellaneous.

Where the guides refer to the designation of regulated radiation areas, they reproduce the rules of the Royal Decree, and add some further details, although the latter are usually not significant in the context of this survey. Only one guide provides some numerical details of controlled areas, the guide on the security and radiation protection of radioactive industrial gammagraphy facilities [2].

In the medical sector, the CSN has published a radiation protection manual which gives the components of a radiation protection programme for medical facilities [3]. This document was used as the basis for the drafting of the radiation protection manual of Madrid University hospital, for example [4].

In the nuclear sector, a guide has been written by a group of experts from facility operators and the authorities with the intention of harmonising the radiation protection rules applied by nuclear power plants[1]. Certain specific features on the designation of regulated radiation areas are defined in this guide and were presented at an ISOE symposium [5] in a communication on practical implementation of European Directive 96/29. The information provided has been supplemented by information from the radiological protection manual of the Almaraz and Trillo nuclear power plants [6, 7] and by the nuclear power plant marking harmonisation guide, published by UNESA (plant operator grouping) [8].

Note: Only quotations from the official English version of the Royal Decree are reproduced below. The texts which were available only in Spanish are not reproduced. Please refer to the official original texts if necessary.

[1] The complete guide was not supplied to us by the CSN. The data used are taken from the ISOE communication and from the extracts of the guide provided to us.

Designation of regulated radiation areas IN THE GENERAL rEgUlationS

1.1. Purpose and principle

The purpose of the designation of areas as controlled areas is to protect the public and workers from exposure to ionising radiation, to prevent the propagation of radioactive contamination, and to prevent radiological accidents or limit their probability and magnitude.

1.2. Types of facility covered by the regulations

Royal Decree 738/2001 refers to all types of facility and to all sectors of activity.

Royal Decree 738/2001 - Title I. General provisions - Article 2. Scope of application
1. This present Regulation shall be applied to all practices that imply a risk deriving from the ionising radiations that proceed from an artificial source, or from a natural radiation source, when the natural radionuclides are, or have been, processed for their radioactive, fissionable, or fertile properties, (...)
Similarly, it shall be applicable to those activities that are developed by external companies, as referred to in Royal Decree 413/1997, of the 21st of March, on the Operational Protection of those External Workers with a Risk of Exposure to Ionising Radiations as a result of their Intervention in the Controlled Area.
2. This present Regulation shall be applicable in the terms referred to in Title IV, to all interventions in cases of radiological emergencies, or in cases of lasting exposure.
3. This present Regulation shall be applicable in the terms referred to in Title VII to all occupational activities not contemplated within section 1, but which suppose the presence of natural sources of radiation, and which give rise to a significant increase in the exposure of workers or members of the public which cannot be dismissed as insignificant in terms of radiological protection.
4. The present Regulation shall not be applicable to the exposure to radon in housing, or to the natural levels of radiation, this is to say, those radionuclides contained in the human body, the cosmic rays at ground level, or to the exposure above ground level due to the radionuclides present in the non altered terrestrial crust.

1.3. Assessment of the nature and magnitude of the risk before designation

The risk assessment prior to delimitation of radiological areas is the responsibility of the facility manager. This assessment is the basis for classification of work areas into various types of area taking into account:

- predictive estimation of annual doses,
- the contamination dispersion risk,
- the probability and magnitude of potential exposures.

The radiological protection measures to be implemented in the defined areas must be appropriate for the type of facility and source and for the magnitude and nature of the risks.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter One. Operational protection of exposed workers.
Article 15 : Principles for the protection of workers
The operational protection of exposed workers shall be based on the following principles:
a) Prior evaluation of the working conditions to determine the nature and magnitude of the radiological risk and to ensure the application of the optimisation principle.
b) Classification of the working places in different areas, taking into account: the evaluation of the expected annual doses, the risk of dispersion of contamination and the probability and magnitude of potential exposures.
c) Classification of exposed workers into different categories, according to their working conditions.
d) Application of the standards and the monitoring and control measures related to the different areas and to the different categories of exposed workers, including individual monitoring, when appropriate.
e) Sanitary monitoring. [2]

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 16 : Establishment of areas

To the effects of radiological protection, the title-holder of the practice shall identify and delimit all the work areas in which there may be a possibility of receiving effective doses that exceed 1 mSv per official year, or an equivalent dose greater than 1/10th of the limits for the crystalline lens, the skin, and the extremities referred to in paragraph 2 of Article 9, and shall establish the applicable radiological protection measures. These measures must be adapted to the nature of the installation, the sources, as well as the magnitude and nature of the risks. The scope of the prevention and monitoring measures, as well as their nature and quality, must be based on the risks associated with the tasks that imply exposure to ionising radiations. [2]

The definition of the areas is the responsibility of the facility manager, who must ensure that the regulations are implemented under the responsibility of the radiological protection service or of the radiological protection technical unit or, if there is no such service or unit, by the person to whom radiation protection duties have been assigned.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 18-4 : Area requisites

The title-holder of the practice is responsible for complying with what is established in paragraphs 1, 2, and 3 of this article, and to ensure that this is carried out under the supervision of the Radiological Protection Service, or the Radiological Protection Technical Unit, and in their absence by the Supervisor or person to whom the radiological protection duties are entrusted. [2]

The facility manager must archive the documents relating to the measures concerning the various controlled and monitored areas.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Three: Evaluation of the exposure – Section 1. Monitoring the work environment.

***Article 26-2*:**

The documents relative to the registration, evaluation and result of the aforementioned monitoring must be archived by the title-holder of the installation who shall ensure that they are at the disposal of the competent authority. [2]

In the nuclear sector, the facility operator must produce a “radiation protection manual” containing all the measures taken to comply with the regulations. This document must be approved by the safety authorities.

1.4. Area types

The Royal Decree defines two types of area: controlled areas and monitored areas. The delimitation criteria are based on the annual dose limits. Division of controlled areas into smaller areas is also covered. Access to areas where the dose rate is less than 0.5 µSv/h is unrestricted.

1.4.1. Controlled area

An area is designated as controlled (green trefoil) if:

- the effective dose received may be greater than 6 mSv per calendar year,
- the equivalent dose may be greater than three-tenths of the annual exposure limits per calendar year defined by the regulations:
    - extremities (hand, forearm, foot, ankle): 500 mSv,
    - skin: 500 mSv (dose averaged over any 1 cm^2 area),
    - eye lens: 150 mSv,
- it is necessary to follow specific work procedures to restrict exposure to ionising radiation, to avoid the dispersion of radioactive contamination or to limit the probability and magnitude of radiological accidents or their consequences.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 17 : Classification of areas

1. The title-holder of the practice shall classify the work areas, in accordance with the exposure risk and taking into account the probability and magnitude of the potential exposures, in the following areas:

a) Controlled area: is the area in which:

1°. There is the possibility of receiving an effective dose greater than 6 mSv per official year, or an equivalent dose greater than 3/10ths of the equivalent dose limits for the crystalline lens, the skin and extremities, as established in paragraph 2 of Article 9, or

2°. It is necessary to follow work procedures whose aim is to restrict exposure to ionising radiation, to avoid the dispersion of radioactive contamination, or to prevent or limit the probability and magnitude of radiological accidents, or their consequences. [2]

Smaller areas may be defined within the green controlled area:

- limited stay area (yellow trefoil) is an area where there is a risk of exceeding the annual dose limits (in the case of continuous presence of a worker in this area):
    - effective dose: 50 mSv over one calendar year and 100 mSv over five consecutive calendar years,
    - equivalent doses defined for the extremities, the skin and the eye lens over one calendar year;
- regulated stay area (orange trefoil) is an area where there is a risk of receiving, over a shorter period, doses exceeding the annual dose limits (effective dose and equivalent doses) and which necessitate special instructions regarding optimisation;
- forbidden access area (red trefoil) is an area where there is a risk of exceeding the annual dose limits (effective dose or equivalent doses) in a single exposure (entering/leaving the area).

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 17-2 : Classification of areas
Furthermore, the controlled areas may be subdivided as follows:
a) Areas of limited stay: are those in which there is a risk of receiving a dose that exceeds the dose limits set in Article 9.
b) Areas of regulated stay: are those in which there is a risk of receiving for short periods of time a dose that exceeds the dose limits set in Article 9, and which require special prescriptions regarding optimisation.
c) Areas of forbidden access: are those in which there is a risk of receiving, in one single exposure, doses that exceed the dose limits set in Article 9. [2]

1.4.2. Monitored area

An area is defined as monitored (blue-grey trefoil) if:
- the effective dose received may exceed 1 mSv over one calendar year,
- the equivalent dose received may exceed one-tenth of an annual exposure limit (per calendar year) defined by the regulations.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 17-1.b : Classification of areas
Monitored area: is an area in which, although not being a controlled area, there is a possibility of receiving effective doses that exceed 1 mSv per official year, or an equivalent dose greater than 1/10th of the equivalent dose limits for the crystalline lens, the skin and extremities, as established in paragraph 2 of Article 9. [2]

Lastly, the Royal Decree states that area classification must always be adjusted to actual conditions. To this end, the area classification must be revised on the basis of variations in the working conditions.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 17-3 : Classification of areas
The classification of the working areas into the established areas must always be updated according to the real existing conditions, to this end the title-holder of the practice shall submit for revision the area classification on the basis of the variations in the working conditions.

1.5. Access conditions

Radiological monitoring must be implemented in the work environments of the controlled and monitored areas, taking account of the nature and magnitude of the radiological risks.

Access to controlled and monitored areas is limited to authorised persons who have been given appropriate instructions concerning the radiological risk. These instructions must conform to the work procedures established in writing by the facility manager.

In the controlled areas:

- if there is a risk of external exposure, the use of an individual dosimeter is mandatory,

- if there is a risk of contamination, the use of personal protective systems is mandatory. Exits from these areas must be equipped with suitable detectors for identifying potential contamination of persons and equipment and, if necessary, applying the appropriate procedures.

In the monitored areas, as a minimum the doses potentially received must be estimated, using area dosimetry.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 18. Area requisites

1. Taking into account the nature and the importance of radiological risks, radiological monitoring must be carried out on the working environment, of the controlled and monitored areas, according to what is established in Article 26. Furthermore, these areas:

a) Shall be adequately delimited and signalled in a manner that makes the risk of exposure in these areas evident. This signalling shall be carried out according to what is established in Annex IV.

b) The access shall be limited to persons authorised to do so, and who have been given adequate instructions as to the existing risk in these areas. In the controlled areas these instructions shall comply with the working procedures, established in writing by the title-holder of the practice.

2. In those controlled areas where there may be:

a) External exposure risk, the use of individual dosimeters shall be compulsory.

b) Contamination risk, the use of personal protection systems, adapted for the existing risk, shall be compulsory. At the exit points from these areas, there shall be adequate detectors to observe any possible contamination of persons or equipment, and if the case arises to adopt the opportune measures.

3. In the monitored areas, at least an estimation of the potential doses received must be carried out, through area dosimetry.

4. The title-holder of the practice is responsible for complying with what is established in paragraphs 1, 2, and 3 of this article, and to ensure that this is carried out under the supervision of the Radiological Protection Service, or the Radiological Protection Technical Unit, and in their absence by the Supervisor or person to whom the radiological protection duties are entrusted.

1.6. Area marking

The monitored and controlled areas must be delimited and marked to make the exposure risks explicitly visible.

If the only risk is of external exposure, the trefoil sign must be surrounded by radial points. If there is a contamination risk, with only a minor external irradiation risk, the background of the trefoil sign must be dotted. If both risks are present, the trefoil must be on a dotted background and surrounded by radial points (examples are given in the nuclear sector part).

Areas are marked with a trefoil, colour-coded according to area type, on a white background surrounded by a border of the same colour as the trefoil.

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices – Chapter Two: Exposure prevention – Section 1. Classification and delimitation of areas.

Article 18. Area requisites

1. Taking into account the nature and the importance of radiological risks, radiological monitoring must be carried out on the working environment, of the controlled and monitored areas, according to what is established in Article 26. Furthermore, these areas:
a) Shall be adequately delimited and signalled in a manner that makes the risk of exposure in these areas evident. This signalling shall be carried out according to what is established in Annex IV. [2]

Royal Decree 738/2001 Title IV. Fundamental principles of operational protection of exposed workers, persons in training and students for the execution of the practices
ANNEX IV - Area signalling

1. The signalling of controlled areas and monitored areas shall be carried out according to what is established in norm UNE-73-302, and according to what is stipulated in this Annex.

2. The exposure risk shall be signalled by its international symbol, a "clover" surrounded by a rectangular border of the same colour as the symbol, and of the same width as the diameter of the inside circumference of the aforementioned symbol.

3) Controlled areas: In the controlled areas the aforementioned clover shall be green on a white background.
a) Areas of limited stay: In these areas the clover shall be yellow on a white background.
b) Areas of regulated stay: In these areas the clover shall be orange on a white background.
c) Areas of forbidden access: In these areas the clover shall be red on a white background.

4. Monitored areas: In the monitored areas the clover shall be blue-gray on a white background.

5. If in any of the areas there should only be external exposure risk, the general clover for the area shall be used surrounded by radial dots; if there is danger of contamination and the risk of external exposure were to be minor, the general clover for the area shall be used on a dotted background; if there were to be a joint risk of contamination and exposure, the general clover for the area shall be used with a border of radial dots on a dotted background.

6. All the signs that correspond to controlled areas, areas of limited stay, areas of regulated stay, and areas of forbidden access, as well as the monitored areas shall be placed in a very visible manner at their entrance and in the significant sites of the areas.

7. For all types of zones, the aforementioned signals shall be complemented by text that indicates the type of area in question, which shall be placed above the sign, whereas underneath the sign, the type of risk shall be indicated.

8. When the outer limits of an area must be signalled temporarily, fences, articulated metal bars or supports through which ropes, chains, tape, etc. may be attached, shall be placed, in the colour that corresponds to the area in question.
9. In the access areas to contiguous areas of different characteristics, the corresponding limits may be signalled on the floor by means of clearly visible lines in the colours that correspond to the areas in question. This aforementioned signalling may be complemented with lighting effects in the appropriate colours for each area.

10. Within the controlled areas and the monitored areas the sources must be signalled.

In the case of industrial radiography [3], the controlled area for mobile systems must be delimited by barriers or adhesive tapes and signposted visibly. A collimator must be used whenever possible. The dose rate in the controlled area must be kept between 7.5 and 20 μSv/h, if possible.

2. NUCLEAR FACILITY RULES

2.1. Area delimitation in the nuclear industry

The ISOE symposium article [5] gives the criteria adopted by a joint authorities-operators working group. These values apply to all nuclear power plants in Spain.

The designation of regulated radiation areas is defined according to the risk of external exposure, the surface contamination and the airborne contamination. The criterion with the highest value defines the area. However, in the case of a combined risk (external exposure and contamination, for example), both risks are marked (refer to the Marking paragraph). The derived air concentration (DAC) values for airborne contamination have been calculated on the basis of an annual exposure limit of 20 mSv/year. It should be noted that the dose rate measurement time criteria are not given. They are also not given in the radiation protection manual of the Almaraz and Trillo nuclear power plants, which reproduces this classification [6].

2.1.1. Unrestricted access area

Unrestricted access areas are those which do not include any equipment or systems that are radioactive or have an influence on the radiological conditions of the area. The access criteria are those defined by the physical and conventional safety of the workers.

The following criteria must be complied with:

- dose rate < 0.5 μSv/h
- no surface contamination risk
- no airborne contamination risk.

2.1.2. Monitored area (blue-grey)

- 0.5 μSv/h ≤ dose rate < 3 μSv/h
- surface contamination averaged over 300 cm^2
    - < 0.4 Bq/cm^2 β/γ
    - < 0.04 Bq/cm^2 α
- no airborne contamination.

Note: The Almaraz radiological protection manual states that in practice there is no monitored area at the Almaraz nuclear power plant, as the radiological conditions at the controlled area boundaries are the same as the conditions for the unrestricted access areas.

2.1.3. Controlled area

Green controlled area:

- 3 μSv/h ≤ dose rate < 25 μSv/h, and
- surface contamination averaged over 300 cm^2
    - < 4 Bq/cm^2 β/γ
    - < 0.4 Bq/cm^2 α, and
- airborne contamination < 0.1 DAC.

Yellow limited stay area:
- 25 μSv/h ≤ dose rate < 1 mSv/h, and
- surface contamination averaged over 300 cm^2
  - < 40 Bq/cm^2 β/γ
  - < 4 Bq/cm^2 α, and
- airborne contamination < 1 DAC.

Orange regulated stay area:
- 1 mSv/h ≤ dose rate < 100 mSv/h, and
- surface contamination averaged over 300 cm^2
  - < 400 Bq/cm^2 β/γ
  - < 40 Bq/cm^2 α, and
- airborne contamination < 10 DAC.

Red forbidden access area:
- dose rate > 100 mSv/h, or
- surface contamination averaged over 300 cm^2
  - > 400 Bq/cm^2 β/γ
  - > 40 Bq/cm^2 α, or
- airborne contamination > 10 DAC.

2.2. **Controlled area access conditions**

The radiation protection manual of the Almaraz and Trillo nuclear power plants [6] states that, with the exception of a few special cases (extreme necessity, such as evacuation of injured persons), as a general rule no persons other than exposed workers are permitted to access the controlled area.

2.2.1. Green controlled area

The green controlled area is limited to the exposed workers category for 'normal' and 'continuous' stays and to category B workers for occasional access.

Visitors and non-exposed workers may still have access limited to areas with low dose rates and contamination levels. They must obtain an authorisation and must always be accompanied by an exposed worker with appropriate radiation protection training.

2.2.2. Yellow limited stay area

Access to limited stay areas is restricted to exposed workers. In certain cases the stay in these areas is subject to a time limit and to an authorisation in the form of a "radiological work permit", including a prior assessment of the risks and the necessary means of protection.

2.2.3. Orange regulated stay area

Access to regulated stay areas is restricted to category A exposed workers. The stay in these areas is subject to a time limit and to an authorisation in the form of a "radiological work permit", including a prior assessment of the risks and the necessary means of protection.

2.2.4. Forbidden access area

Entry into the forbidden access area requires a “radiological work permit” drawn up by the head of the radiation protection service and the Director of operations.
These areas must be closed off with physical barriers and, if possible, with a locking system, the keys of which are held by the administration.

For access to the controlled area, exposed workers must:

- be registered as an exposed worker at the nuclear power plant
- wear a direct-reading dosimeter
- wear appropriate protective clothing.

2.3. Marking

The radiation protection manual of the Almaraz and Trillo nuclear power plants [6] reproduces the requirements of the general regulations. It also gives information relating to the marking of hot spots located in controlled areas. Hot spots must be marked by applying a specific procedure (procedure PS-CR-02.05 Marking and delimitation of radioactive and contaminated areas and equipment [7]), according to the irradiation risk. In general, it is considered that a hot spot must be marked in an area if its dose rate is ten times higher than the ambient radiation level of the area.

When temporary work is carried out in an area, temporary marking may be used to mark the boundaries of the area. The signs and barriers used (metal bars, cords, chains, tapes, etc.) must have the colour of the area in question or show the measured dose rate and contamination values.

Regarding access between different types of adjacent area, the area boundaries can be marked visibly on the floor using the colours corresponding to the areas involved. These markings may be supplemented by lighting of appropriate colour for the areas involved.

The figures below are taken from the guide published by UNESA for harmonisation of the marking and delimitation of areas in nuclear power plants [8].

The figure below is an example of yellow area (limited stay area) marking, with irradiation risk. If necessary, this sign is supplemented by a poster giving further information about the area (photograph, hot spots, dose rates, etc.).

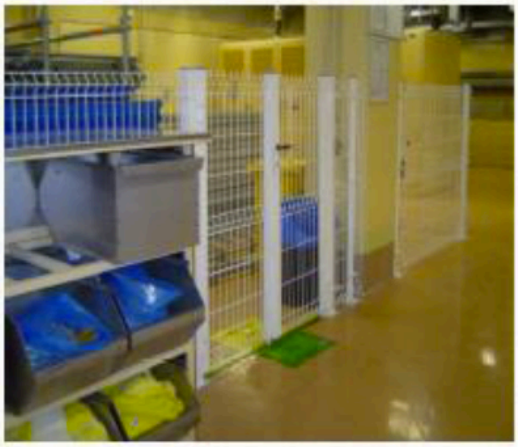
The figure below shows the sign for an area with irradiation and surface contamination risks.

The figure below shows the sign for a hot spot.

The photographs below show the types of area delimitation.

Cuando se deban señalizar con carácter temporal los limites de una zona, se emplearán vallas, barras metálicas articuladas o soportes por los que se hagan pasar cuerdas, cadenas, cintas etc., que tendrán el color correspondiente a la zona de que se trate. (Punto 8 del Anexo IV del RSPSRI)

DELIMITACIÓN PROVISIONAL DE ÁREA RADIOLÓGICA



DELIMITACIÓN A LARGO PLAZO DE ÁREA RADIOLÓGICA

3. RULES IN THE MEDICAL SECTOR

3.1. Area delimitation in the medical sector

The area designation criteria given in the CSN medical radiation protection manual [3] are those defined in the general regulations for monitored and controlled areas. A specific classification is also proposed.

The classification of X-ray generators is valid only during operation of the apparatus. Access to the room is unrestricted if the apparatus is not operating. Specific marking must be implemented for the designation of the areas according to the state of the system.

Conventional radiology
- monitored area: control station protected by a physical barrier
- controlled area: inside the radiography room

Interventional radiology
- monitored area: control station protected by a physical barrier
- limited stay area: inside the room

Teletherapy
During equipment operation
- monitored area: control station
- forbidden access area: inside the room

When the equipment is not being used
- unrestricted access area: control station
- controlled area: inside the room

Brachytherapy
- controlled area: source preparation room and access to rooms
- limited stay area: rooms occupied by patients with sources

Nuclear medicine
- monitored area: radioactive waste storage
- limited stay area: rooms occupied by patients receiving metabolic treatment
- controlled area: hot room, dose administration area, areas where patients who have received injections move around and stay.

This classification is used at the Madrid hospital, with the addition of monitored area classification for the laboratories using radioactive materials for in vitro experiments.

3.1.1. Access conditions

According to the Madrid hospital radiation protection manual [4], to access controlled areas exposed workers must have:
- means of detecting and measuring radiation or contamination,
- appropriate protective equipment to avoid any external irradiation,
- appropriate personal protection (coverall, gloves, bonnet, etc.) when there is a contamination risk,
- specific equipment necessary in the case of an emergency.

3.2. Marking

The Madrid hospital radiation protection manual [4] reproduces the requirements of the general regulations and stipulates that, for areas without permanent designation, a sign must give the applicable restrictions and their application conditions. Mobile X-ray equipment must have a sign giving its characteristics, the risks and the limits of use.

In addition, patients undergoing diagnostic tests or treatments must receive the necessary information and means to avoid accidental radiation exposure.

3.3. Specific measures for limiting the contamination risk

If there is a risk of contamination, strict compliance with the rules on wearing specific clothes, gloves and shoes and with all the measures to prevent the risk is necessary.

4. REFERENCES

[1] **Regulation on Sanitary Protection against Ionising Radiations** Published in the Spanish Official State Gazette number 178, of the 26th of July 2001 - **Royal Decree 738/2001, of the 6th of July,** which approves the Regulation on Sanitary Protection against Ionising Radiation

[2] **Guía de Seguridad y protección radiológica de las instalaciones radiactivas de gammagrafía industrial,** Guía 5.14,Madrid, 8 de octubre de 1998, CSN.

[3] **Manual general de protección radiológica,** version finale 16 Septembre 2002

[4] **Manual de protección radiológica Hospital Universitario Ramon y Caja,** Hospital universitario principe de asturias, Instituto madrileño , de la salud – madrid, 30 octobre 2002

[5] **Practical implementation of the 96/29 Euratom Directive to the Radiation Protection programs of Spanish Nuclear Power Plants,** By O. Guzmán, T. Labarta, J.J. Montesinos, Mª L. Rosales, Mª J. Muñoz, I. Amor / CSN / Spain

[6] **Manual de protección radiológica, DAL-06 – Centrales nucleares Almaraz – Trillo**

[7] **Clasificación, señalización y delimitación de zonas y equipos radioactovos et conaminados -** PS-CR-02.05 **- Centrales nucleares Almaraz – Trillo, 2009**

[8] **Armonización de la señalización de riesgos radiológicos en las centrales nucleares españolas, UNESA CEN-32 – Noviembre 2009.**

COUNTRY SHEET – UNITED STATES

CONTENTS

1. INTRODUCTION

The United States regulations on the designation of controlled and supervised areas are set out in the U.S. Nuclear Regulatory Commission (NRC) Regulations Title 10, Code of Federal Regulations – Part 20 – Standards for protection against radiation (10 CFR 20) [1]. They apply to all types of facility.

The regulations are reinforced by regulatory guides published by the NRC. For the nuclear industry, Regulatory guide 8.38 [2] defines the access conditions to high radiation and very high radiation areas, supplementing the 10 CFR 20 regulations. In addition, each nuclear power plant operator has its own internal procedures: those of Exelon (Braidwood and other plants) [3, 4] and AEP (Cook plant) [5,6] are presented briefly in this data sheet.

The Departments of Health of each state also publish their own regulations. For example, in New York State, part 16 of the New York State Sanitary Code [7] covering ionising radiation reproduces 10 CFR 20 in its entirety and adds some details, particularly with regard to the medical sector. New York State also publishes guides (*Radiation Guide)* for applicants for licences for the various practices using ionising radiation (e.g. use of sealed sources in industrial radiography, cyclotron, X-rays). These guides specify the content of the licence application. However, the information on classification of areas in the guides consulted is not more specific than the information in the regulations.

2. DESIGNATION OF REGULATED RADIATION AREAS IN THE GENERAL REGULATIONS

2.1. Purpose and principle

The text of 10 CFR 20 is relatively vague about the purpose and principle of designating areas for radiological protection purpose. It states that one of the goals of the regulations in the area of protection against ionising radiation is to ensure that the total dose of an individual does not exceed the stipulated benchmarks for protection against radiation. Similarly, the definition of a controlled area is limited to an area located outside a restricted access area but within the boundaries of the site, access to which can be limited by the licensee for any reason, without giving further details of the purpose of such limitation. In contrast, the regulations state that areas are classified as restricted areas, access to which is limited in order to protect persons against excessive risks resulting from exposure to radiation and to radioactive materials.

2.2. Types of facility covered by the regulations

The 10 CFR 20 regulations cover all types of facility and all sectors of activity. Regulatory guide 8.38 covers nuclear power plants only.

2.3. Assessment of the nature and magnitude of the risk before designation

Risk assessment before delineation of radiological areas is the responsibility of the licensee. This assessment enables activities with a risk due to ionising radiation to be carried out. Each licensee must make or cause to be made preliminary checks to:

- verify compliance with the 10 CFR 20 regulations; and
- evaluate:
    - radioactivity levels,
    - concentrations or quantities of radioactive materials,
    - potential radiological hazards.

10 CFR 20 : Subpart F – Surveys and Monitoring
§ 20.1501 General

Each licensee shall make or cause to be made, surveys that:
(1) May be necessary for the licensee to comply with the regulations in this part; and
(2) Are reasonable under the circumstances to evaluate:
(i) The magnitude and extent of radiation levels; and
(ii) Concentrations or quantities of radioactive materials; and
(iii) The potential radiological hazards. [1]

2.4. Area types

The 10 CFR 20 regulations define various types of area and their characteristics. It should be noted that these area types are described only in the definitions section of 10 CFR 20 (10 CFR 20 : Subpart A – General Provisions - § 20.1003 Definitions)

The following areas are those similar to the European definitions of supervised areas and controlled areas:

Restricted area
Restricted area means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

As this area is intended to protect persons against radiation or contamination, but in a very generic way (without designation criteria), it can be considered similar to a supervised area.

Unrestricted area
Unrestricted area means area, access to which is neither limited nor controlled by the licensee.

Radiation area
Radiation area means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

High radiation area
High radiation area means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates.

Very high radiation area
Very high radiation area means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or 1 meter fro many surface that the radiation penetrates.
(Note: at very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems[2] and sieverts))

[2] In practice, in the United States the old units (rem, rad) are still used.

Airborne radioactivity area
Airborne radioactivity area means a room, enclosure, or area in which airborne radioactive materials composed wholly or partly of licensed materials, exist in concentrations[3]*:*
(1) In excess of the derived air concentrations (DACs) specified in appendix B, to §§ 20.1001 – 20.2401, or
(2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours of an individual is present in a week , an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

Controlled area
Controlled area means an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason..

2.5. Controlled area boundary characteristics and access conditions

The 10 CFR 20 regulations describe the area boundary characteristics for all fields of activity.

The control of access to high ratiation area ins indicated in 10 CFR 20 : Subpart G – Control of Exposure From External Sources in Restricted Areas - § 20.1601 Control of access to high radiation area

(a) The licensee shall ensure that each entrance or access point to a high radiation area has one or more of the following features:

> *(1) A control device that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep-dose equivalent of 1 mSv in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.*
>
> *(2) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or*
>
> *(3) Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.*

(b) In place of the controls required by paragraph (a) of this section for a high radiation area, the licensee may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

(c) A licensee may apply to the Commission for approval of alternative methods for controlling access to high radiation areas.

(d) The licensee shall establish the control required by paragraphs (a) et (c) of this section in a way that does not prevent individuals from leaving a high radiation area.

(e) Control is not required for each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with the regulations of the Department of Transportation provided that:

[3] In practice, in the Unite-States, DAC and ALI are calculated based on an annual dose limit of 50 mSv

(1) The packages do not remain in the area longer than 3 days, and

(2) The dose rate et 1 meter from the external surface of any package does not exceed 0,01 rem (0,1 mSv) per hour.

(f) Control of entrance or access to rooms or other areas in hospitals is not required solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program. [1]

For very high radiation areas, in addition to the requirements for high radiation areas given above, *the licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 graysGy) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates (§ 20.1602)*

In addition, details are given of respiratory protection and means of control for reducing internal exposure in restricted areas.

To manage and control the concentration of radioactive materials in the air, the licensee must use engineering processes (for example containment, decontamination or ventilation), as far as possible (§ 20.1701).

Other means of control may nevertheless be used (§20.1702) :
(a) When it is not practical to apply process or other engineering controls to control the concentrations of radioactive material in the air to values below those that define an airborne radioactivity area, the licensee shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring and limit intakes by one or more of the following means:

(1) Control of access
(2) Limitation of exposure time;
(3) Use of respiratory protection equipment; or
(4) Other controls.

(b) If the licensee performs an ALARA analysis to determine whether or not respirators should be used, the licensee may consider safety factors other than radiological factors. The licensee should also consider the impact of respirator use on workers' industrial health and safety. [1]

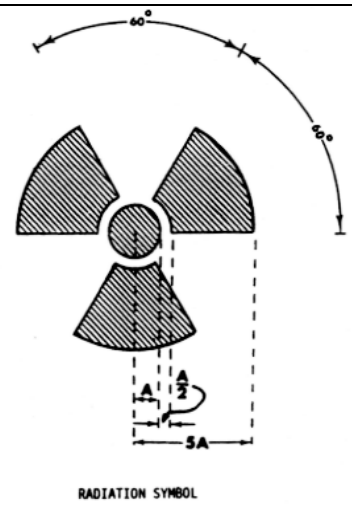
2.6. Area marking

The signs to be used and the marking requirements are described in 10 CFR 20. The standard radiation symbol (trefoil) must be used unless otherwise authorised by the NRC, and the colours used must be magenta, purple or black on a yellow background.

In addition to the signs and labels prescribed in this section, the licensee may, if it considers it necessary, provide additional information on or near the required signs or labels, to inform individuals of the potential exposure to radiation and minimise their exposure. (

10 CFR 20 : subpart J :- Precautionary Procedures
§ 20.1901 Caution signs

(a) ***Standard radiation symbol.*** *Unless otherwise authorized by the Commission, the symbol prescribed by this part shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed by this part is the three-bladed design:*



RADIATION SYMBOL

(1) Cross-hatched area is to be magenta, or purple, or black, and

(2) The background is to be yellow.

(b) ***Exception to color requirements for standard radiation symbol.*** *Notwithstanding the requirements of paragraph (a) of this section, licensees are authorized to label sources, sources holders or device components containing sources of licensed materials that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.*

(c) ***Additional information on signs and labels.*** *In addition to the contents of signs and labels prescribed in this part, the licensee may provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposure and to minimize the exposures.*

The posting requirements are the following (§20.1902):

(a) ***Posting of radiation areas.*** *The licensee shall post each radiation area with a conspicuous sign or sign bearing the radiation symbol and the words "CAUTION, RADIATION AREA".*

(b) ***Posting of high radiation areas.*** *The licensee shall post each high radiation area with a conspicuous sign or sign bearing the radiation symbol and the words "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA".*

(c) ***Posting of very high radiation areas.*** *The licensee shall post each very high radiation area with a conspicuous sign or sign bearing the radiation symbol and the words "GRAVE DANGER, VERY HIGH RADIATION AREA".*

(d) ***Posting of airborne radiation areas.*** *The licensee shall post each airborne radiation area with a conspicuous sign or sign bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIATION AREA" or "DANGER, AIRBORNE RADIATION AREA".*

(e) ***Posting of areas or rooms in which licensed materials is used or stored.*** *The licensee shall post each area or room in which there is used or stored an amount of licensed materials exceeding 10 times the quantity of such material specified in appendix C to part 20 with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL (S)"or "DANGER, RADIOACTIVE MATERIAL (S)".*

There are exceptions to the posting requirements described above (§20.1903):

a) A licensee is not required to post caution signs in areas or rooms containing radioactive materials for period of less than 8 hours, if each of the following conditions is met:

(1) The materials are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to radiation or radioactive materials in excess of the limits established in this part; and
(2) The area or room is subject to the licensee's contro

(b) Room or other areas in hospitals that are occupied by patients are not required to be posted with caution signs pursuant to § 20.1902 provided that the patient could be released from licensee control pursuant to § 35.75 of this chapter.

The patient may be released if the total effective dose that another individual might receive from the patient is less than 5 mSv. The licensee may give instructions to the patient or to his or her family if the effective dose due to exposure to the patient might be greater than 1 mSv.

(c) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level at 30 centimeters from the surface of the source container or housing does not exceed 0,005 rem (0,05 mSv) per hour.

(d) Rooms in hospital or clinics that are used for teletherapy are exempt from the requirement to post caution signs under §20.1902 if:
(3) Access to the room is controlled pursuant to 10 CFR 35.615; and
(4) Personnel in attendance take necessary precautions to prevent the inadvertent exposure of workers, other patients, and members of the public to radiation in excess of the limits established in this part.

Access to the room is controlled in accordance with 10 CFR 35.615 which stipulates that: each entrance must be closed by a door and must have electrical locking. A check must be performed before each entry to determine whether the radiation level is at the background level. Each treatment room must have a video surveillance system and an intercom for monitoring the patient during irradiation. For medium dose rates (2 Gy/h < dose rate < 12 Gy/h at the prescribed point or surface) and pulsed dose rates, the licensee must require attendance by a medical physicist during the procedure. For high dose rates (dose rate > 12 Gy/h at the prescribed point or surface), in addition to the medical physicist, an individual authorised to use the apparatus must be present.

3. NUCLEAR FACILITY RULES

3.1. Area types

3.1.1. Case of the Cook nuclear power plant (operator AEP)

Additional areas and criteria are defined by the operator [5, 6].

Restricted area
The following are restricted areas:
- all areas in which radioactive materials are stored, handled or processed, or areas in which the dose rates are greater than or equal to 15 μSv/h,
- all areas to which access is controlled in order to protect individuals against the risks of exposure to radiation and/or to radioactive materials.

Radioactive material area (RMA)

Radiation area
All areas where the dose rate is greater than or equal to 45 μSv/h at 30 cm and less than 0.9 mSv/h at 30 cm.

High radiation area
All areas where the dose rate is greater than or equal to 0.9 mSv/h at 30 cm and less than 9 mSv/h at 30 cm.

Locked high radiation area (LHRA)
All areas where the dose rate is greater than or equal to 9 mSv/h at 30 cm and less than 5 Gy/h at 1 metre.

Locked very high radiation area (LVHRA)
All areas where the dose rate is greater than or equal to 5 Gy/h at 1 metre.

Neutron exposure area (NEA)
All areas where the dose rate from neutron radiation is greater than or equal to 20 mSv/h.

Contaminated area (CA)
All areas in which loose surface contamination exceeds either of the following limits:
- greater than or equal to 1000 dpm[4]/100 cm^2 (16.7 Bq/100 cm^2) and less than 100,000 dpm/100 cm^2 (1.6 kBq/100 cm^2) of beta/gamma activity, or
- greater than or equal to 20 dpm/100 cm^2 (0.3 Bq/100 cm^2) of alpha radioactivity.

Airborne radioactivity area
All areas for which either of the following conditions is met:
- the sum of particulate, iodine and tritium airborne radioactivity concentration are greater than or equal to 0.3 DAC, or
- the sum of particulate, iodine, tritium and noble gases concentrations, as applicable, are greater than or equal to 1.0 DAC.

High contamination area (HCA)
All areas where the average loose surface contamination levels are greater than or equal to 100,000 dpm/100 cm^2 (1.6 kBq/100 cm^2) of beta/gamma activity.

Hot spot
A location is designated as a hot spot when normally accessible components have dose rates greater than or equal to 1 mSv/h on contact and five times greater than the area dose rate at 30 cm.

3.1.2. Case of the operator Exelon

The operator Exelon uses different criteria.

High radiation area
Any area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates.

[4] Disintegrations per minute

Level 1 locked high radiation area
Any area accessible to individuals in which deep dose equivalent rates are greater than or equal to 1 rem per hour (10 mSv/h) (but less than 500 rads (Gy) at 1 meters) in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates.

Level 2 locked high radiation area
Any area accessible to individuals in which deep dose equivalent rates are greater than 15000 mrem per hour (15 mSv/h) (but less than 500 rads (Gy) at 1 meters) in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates and other areas as designated by the Radiation Protection Manager.

3.2. Area boundary characteristics in the nuclear sector

Regulatory guide 8.38 gives details of the characteristics of high and very high radiation areas [2].

The access control procedures for these areas must cover at least the following items (§1.2.1 – Access Control Procedures) :

- *job planning*
- *radiation protection coverage*
- *survey techniques and frequencies*
- *training of workers*
- *prework briefing*
- *frequency for updating radiation work permits or their equivalent*
- *placement of measurement and alarm dosimeters.*

Physical controls may also be introduced in these areas (§1.5 – Physical controls) :

Physical barriers (such as chain link fencing or fabricated walls) may be used to prevent unauthorized personnel access to high and very high radiation areas.

Barriers used to control access to high radiation areas should provide reasonable assurance that they secure the area against unauthorized access and cannot be easily circumvented. (That is, an individual who incorrectly assumes, for whatever reason, that he or she is authorized to enter the area, would be unlikely to disregard and/or circumvent the barrier.) A fence that is 2 meters (approximately 6 ft) high would normally be adequate to control access to a high radiation area at a nuclear power plant.

To the extent practicable, physical barriers should completely enclose very high radiation areas in a manner that is sufficient to thwart undetected circumvention of the barrier. That is, fencing around very high radiation areas should extend to the overhead and preclude anyone from climbing over the fencing. Entrances or access points to these areas should be controlled, as described in Regulatory Positions 2 through 4. Physical controls should be established that do not preclude personnel access to these areas when access is required to respond to emergencies.

3.3. Access conditions in the nuclear sector

In Regulatory guide 8.38, further details are given about access to high and very high radiation areas (LHRA, VHRA). In 10 CFR 20 §20.1601, various options are given for limiting access to high radiation areas; the option most used in nuclear power plants is to keep the area closed.

A large facility such as a nuclear power plant can set up access controls compatible with the use of a radiological work permit or another equivalent programme.

Each high radiation area, as defined in 10 CFR Part 20, should be barricaded and conspicuously posted as a high radiation area, and entrance thereto should be controlled by requiring issuance of an RWP or equivalent. Individuals trained and qualified in radiation protection procedures (e.g., a health physics technician) or personnel continuously escorted by such individuals may be exempted from this RWP requirement while performing their assigned duties in high radiation areas where radiation doses could be received that are equal to or less than 1.0 rem (0.01 Sv) in 1 hour [measured at 30 centimeters (11.8 in.) from any source of radiation] provided that they are otherwise following plant radiation protection procedures, or a general radiation protection RWP, for entry into such high radiation areas. The barrier may be a rope, a tape or any other conspicuous and secure obstacle that completely surrounds the area and blocks entry to it.

In addition, areas that are accessible to personnel and that have radiation levels greater than 1.0 rem (0.01 Sv) [but less than 500 rads (5 Gy) at 1 metem (3.3 ft)] in 1 hour at 30 cm (11.8 in.) from the radiation source, or from any surface penetrated by the radiation, should be provided with locked doors to prevent unauthorized entry, and the keys should be maintained under the administrative control of the shift supervisor on duty or health physics supervisor. Doors should remain locked except during periods of access by personnel under an approved RWP that specifies the dose rates in the immediate work areas and the maximum allowable stay time for individuals in that area.

Individual high radiation areas that are accessible to personnel, which could result in radiation doses greater than 1.0 rem (0.01 Sv) in 1 hour, and that are within large areas where no enclosure exists to enable locking and where no enclosure can be reasonably constructed around the individual area should be barricaded and conspicuously posted.

3.3.1. Case of the Cook nuclear power plant

Each entrance to a LHRA or a VHRA shall be controlled by a lock and key unique to that access point. The locking mechanism for these access points may consist of:

- The installed lock core in the door/gate, provided the electronic lock control system has been disabled for that door/gate
- An external locking mechanism (chain & padlock, hasp & lock, bar & lock) or other mechanisms approved by an RP Supervisor

The electronic lock control system shall not be used as the sole lock control mechanism on LHRA or VHRA access points.

If access to a LHRA cannot be closed physically by a key-operated locking system, it must be marked as follows:

- delineation of the area (physical barrier or rope)
- conspicuous signs on all accessible sides
- installation of a flashing light system or posting of a security guard continuously at the access to the area.

3.3.2. Special case of the operator Exelon

Access to LHRAs must be delimited by a solid lockable barrier. If there is no permanent door, the access barrier must consist of a chain or removable walls. The barriers must ensure the security of the area against unauthorised access and must not be easy to circumvent.

3.4. Marking in the nuclear industry

A flashing alarm must indicate any high or very high radiation area where the dose rate exceeds or could exceed 10 mSv/h at 30 cm from the source or from any surface penetrated by radiation.

3.4.1. Case of the Cook nuclear power plant

The areas at the Cook nuclear power plant are marked as follows.

Restricted area
If the area is marked only because of dose rates, the signs must state that the area is exempt from any contamination control requirement. It is marked by a sign "CAUTION – Restricted area".

Radioactive material area (RMA)
An RMA must be defined when:
- the area is designated for use or storage of radioactive materials (with exceptions),
- the area is marked as restricted (no exception).

The exceptions are as follows:
- rooms or areas in which the materials are stored for less than 8 hours, a person is present continuously in the area to prevent exposure of individuals to doses greater than the limits, and the area is under the licensee's control,
- when there is specific marking for radioactive sources.

RMAs are marked by a sign "CAUTION – Radioactive materials area".

Radiation area
Radiation areas are marked by a sign "CAUTION – Radiation area".

High radiation area
High radiation areas are marked by a sign "DANGER – High radiation area".

Locked high radiation area
Locked high radiation areas are marked by a sign "DANGER – Locked high radiation area".

Locked very high radiation area
Locked very high radiation areas are marked by a sign "GRAVE DANGER – Very high radiation area".

Neutron exposure area
Neutron exposure areas are marked by a sign "CAUTION – Neutron exposure area".

Contamination area
Contamination areas are marked by a sign "CAUTION – Contamination area".

Airborne radioactivity area
Airborne radioactivity areas are marked by a sign "CAUTION – Airborne radioactivity area".

High contamination area
High contamination areas are marked by a sign "CAUTION – High contamination area".

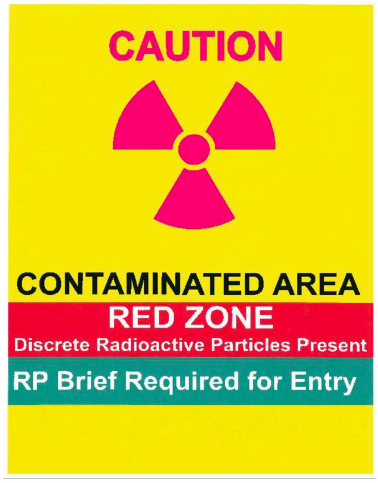
3.4.2. Case of the operator Exelon

In its reference documentation, Exelon defines the signs that must be posted for the various areas. The areas are marked according to the rules laid down in 10 CFR 20.

Locked high radiation area
Locked high radiation areas are marked by a sign "CAUTION – Locked high radiation area" or "DANGER – Locked high radiation area".

Contamination area
Contamination areas are marked by a sign "CAUTION – Contaminated area".

At the entrance to a contamination area, in addition to the sign described previously, a "Red Zone" may be added when the non-fixed contamination could exceed 500,000 dpm (8.3 kBq). A "Yellow Zone" may also be identified and marked around a Red Zone.



4. REFERENCES

[1] U.S. Nuclear Regulatory Commission Regulations: Title 10, Code of Federal Regulations – Part 20: Standards for protection against radiation

[2] U.S. Nuclear Regulatory Commission Regulations: Regulatory Guide 8.38: Control of access to high and very high radiation areas in nuclear power plants

Exelon procedure
[3] Radiological posting, labelling, and marking standard – RP-AA-376 – Revision 6
[4] RP-AA-376-1001, Rev 006, RADIOLOGICAL POSTING, LABELING AND MARKING STANDARD

AEP procedures (Cook)
[5] High, Locked High, and Very High Radiation area access – PMP-6010-RPP-003; Rev 20
[6] Radiological Posting – 12-THP-6010-RPP-418, rev16.

[7] New-York State Sanitary Code, Part 16 Licensing radioactive materials, April 18, 2001.

Additional documents to be consulted on the medical part (payment required):

- NCRP, Report No. 147 - Structural Shielding Design for Medical X-Ray Imaging Facilities (2004)

- NCRP, Report No. 151 - Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities (2005)

- NCRP, Report No. 148 - Radiation Protection in Veterinary Medicine (2004)

- NCRP Report No. 145 - Radiation Protection in Dentistry (2003)

COUNTRY SHEET - FINLAND

CONTENTS

1. INTRODUCTION

The Finnish regulations on the designation of regulated radiation areas are part of the Radiation Act [1], which covers the use of all radiation (ionising and non-ionising) and the other practices that cause or may cause exposure to radiation dangerous for human health.

These general regulations are not very prescriptive: they are supplemented by two regulatory guides which define the management of supervised and controlled areas and the marking to be used: guide ST 1.3 *Warning Signs for radiation sources* [2] and guide ST 1.6 *Operational Radiation Safety* [3].

To reinforce and define the implementation of the regulations in the various sectors, guides have been published by the authorities (STUK). They are based on guides ST 1.3 and ST 1.6 but clarify the specific aspects of the area covered. The following guides should be noted in particular:

- ST 2.2 Radiation safety of radiotherapy equipment and treatment rooms [4]
- ST 3.2 Mammography equipment and their use [5]
- ST 3.6 Radiation safety in X-ray facilities [6]
- ST 5.1 Radiation safety of sealed sources and devices containing them [7]
- ST 5.6 Radiation safety in industrial radiography [8]
- ST 6.1 Radiation safety when using unsealed sources [9]

In the nuclear industry, a specific guide has been published by the authorities: YVL 7.9 *Radiation protection of workers at nuclear facilities* [10].

The quotation of these regulations come from their English translation as provided by the Finnish Safety Authority STUK. Please refer to the official original texts if necessary.

2. DESIGNATION OF REGULATED RADIATION AREAS IN THE GENERAL REGULATIONS

2.1. Purpose and principle

The Finnish regulations give little information about the principle of the classification of areas. Area designation is included in the series of measures intended to ensure radiation protection of workers and other persons in places where radiation is used (guide ST 1.6 [9]).

2.2. Types of facility covered by the regulations

The Radiation Act covers the use of radiation (ionising and non-ionising) and the other practices that result or may result in exposure to radiation dangerous for human health.

The various regulatory guides cover different sectors and specific uses of certain equipment.

In the field of industrial radiography, two types of installation are defined:

- enclosed installation: the radiography apparatus is placed in a shielded enclosure which only authorised persons can enter,
- open installation: radiography is performed in an isolated and guarded area, without fixed barriers such as a wall.

2.3. Assessment of the nature and magnitude of the risk before designation

Risk assessment is the responsibility of the responsible party i.e.:

- the licensee,
- any company that uses ionising radiation in its activities,
- any employer or self-employed worker involved in practices using ionising radiation.

The radiation safety officer must be consulted for the risk assessment. When necessary, a qualified medical physicist for the medical use of radiation or a qualified expert may participate in this assessment.

ST 1.6 § 2.1 The responsible party shall be responsible for safety – Practices shall be planned and risks shall be identified in advance

The responsible party shall plan and implement all radiation protection measures necessary.
When radiation safety measures are being planned and implemented, the responsible party shall consult the radiation safety officer. When necessary, other experts shall also be consulted in advance, such as a medical physics expert for medical use of radiation, and a qualified expert in other uses of radiation when such an expert has been nominated. [3]

The classification (of areas) *shall take into account (ST 1.6 § 2.1):*

- *the nature of the use of radiation sources,*
- *the estimated annual doses caused by the practice,*
- *the hazard of contamination, and*
- *the potential exposure.*

In addition, attention shall be paid to the possibility of an abnormal event, which might result in radiation exposure high in comparison with the exposure caused by normal operations

The delineation of supervised areas and the adequacy of protection measures must be ensured by regular checks and measurements. In supervised areas, contamination checks must be performed regularly when unsealed sources are being used.

For nuclear facilities, guide YVL 7.9 [10] adds that the area designation must be established on the basis of measurements of dose rate and of airborne activity and surface contamination concentrations.

2.4. Area types

The Radiation Act stipulates that the employer must, if necessary, designate two types of area:

- controlled area
- supervised area.

The Radiation Act does not define the area delineation and designation criteria. These are defined in guide ST 1.6 on the characteristics of supervised and controlled areas.

Radiation Act - Chapter 9 (23.12.1998/1142) -Radiation work
Section 32 (23.12.1998/1142) Protection of workers

The responsible party shall plan and implement protection of workers according to the following principles:

- *the radiation exposure to which workers are subjected and the factors affecting this exposure shall be investigated in advance, also having regard to exceptional working conditions,*
- *working areas shall, where necessary, be classified as controlled areas and supervised areas, and*
- *workers who must be individually monitored for radiation exposure shall be classified in a separate group (category A).*

The principles for classifying workers and monitoring radiation exposure shall be stipulated by Decree. STUK shall specify more detailed requirements and issue instructions for the protection of workers and the monitoring of radiation exposure.

2.4.1. Controlled area

A controlled area is an area in where during regular or temporary stay, *(ST 1.6 § 3.1)*:
- *the effective dose for a worker exceeds or may exceed 6 mSv per year, or*
- *the equivalent dose to the lens of the eye 45 mSv per year, and*
- *the equivalent dose to the hands, feet and skin 150 mSv per year,*

allowing for the possibility of a work-related incident resulting in abnormal radiation exposure;

An area may also be designated as controlled if *due to a radiation and contamination hazard, working requires special safety instructions and procedures*

2.4.2. Supervised area

An area is designated as "supervised" if it is not designated as a controlled area but in which *(ST 1.6 § 3.1)*:
- *the annual effective dose of a worker may exceed 1 mSv, or*
- *the annual equivalent dose to the eye lens may exceed 15 mSv, or*
- *the annual equivalent dose to the hands, feet and skin may exceed 50 mSv.*

2.5. Area boundary characteristics

The various areas may be separate from each other. Area designations may be temporary, for the duration of a specific procedure.

Controlled areas must be delineated. Unauthorised access must be avoided by structures, security locking or access control.

In the nuclear industry, controlled areas other than the lowest-risk zones must be locked, or control must be implemented at the area boundary, to avoid unauthorised persons entering the controlled area.

2.6. Controlled area access conditions

Access to controlled *shall be restricted to those individuals with appropriate training who are required and essential for the work in the area and fully aware of the safety instructions to be observed as well as the radiation or contamination hazards associated with staying or working in the area (ST 1.6 § 3.2).*

Anyone working in a controlled area repeatedly or for long periods must be at least 18 years old.

Students and apprentices in the ages of 16–17 may participate in the use of radiation sources in these areas insofar as it is necessary for their vocational training (ST 1.6 § 3.2).

2.7. Area marking

Radiation sources in a controlled or supervised area containing radioactive materials must be marked, giving essential information and indicating the risks associated with each source (radionuclide and activity, date, dose rate, contamination, etc.).

The regulatory guide stipulate that *(ST 1.6 § 3.2)*:

- *It is good practice to use a specific "Controlled Area" sign which also displays a warning sign indicating radiation hazard.*
- *A specific sign is not required, however, if the markings show otherwise that the area is controlled. In the context of medical use of radiation, an acceptable marking consists of, for example, the marking "X-Ray examination room" or "Radiotherapy room". In an operating room or hospital ward or in industrial use of radiation, an acceptable marking consists of a sign set up for the time of irradiation to indicate the radiation hazard.*
- *The warning markings, alarm lights and acoustic signals in use shall clearly indicate any radiation sources in operation.*

3. NUCLEAR FACILITY RULES

3.1. Delineation of controlled areas

Additional criteria are defined in guide YVL 7.9 with regard to supervised and controlled areas in nuclear facilities. Supervised and controlled areas must be delineated after systematic measurements of dose rate, surface contamination and airborne contamination.

YVL 7.9 § 5.1 Area and zone division based for zone division
Dose rate measurements and determinations of the concentration of airborne activity and surface contamination (surface activity) shall be systematically conducted at the facility. Based on the results of measurements, the workplaces are classified into controlled and supervised areas. Area outside of the controlled and supervised areas is an uncategorised area in terms of radiation protection.

3.1.1. Controlled areas

The controlled area definition criteria are as follows:

- a dose rate greater than 3 µSv/h, or
- persons working in the area for 40 h per week may receive an internal dose greater than 1 mSv/year.

YVL 7.9 § 5.3 Area and zone division based on radiation conditions at the faculty - Controlled area

At least those premises of the facility, where the external radiation dose rate may exceed a value of 3 µSv/h or where a 40 hour weekly stay may cause an internal radiation dose exceeding 1 mSv per year, shall be defined as a controlled area. [10]

The premises of the controlled area shall be divided into zones based on external dose rate, surface contamination and concentration of airborne activity. There shall be at least three zones:

- lowest-risk zone (for all criteria):
  - *external dose rate ≤ 25 μSv/h*
  - *surface contamination:*
    - *beta emitters ≤ 4 Bq/cm²*
    - *alpha emitters ≤ 0.4 Bq/cm²*
  - *airborne activity ≤ 0.3 DAC*

- highest-risk zone (if any of the criteria are met):
  - *external dose rate ≥ 1 mSv/h*
  - *surface contamination:*
    - *beta emitters ≥ 40 Bq/cm²*
    - *alpha emitters ≥ 4 Bq/cm²*
  - *airborne activity ≥ 30 DAC*

- at least one additional zone between these two zones.

The external dose rate, the surface contamination or the airborne radioactivity concentration may locally exceed the designation limit if the zone in question is separated by access barriers and is marked with signs indicating the radiological condition, the potential time limits on workers in the zone and the protection equipment required.

The DAC is determined on the basis of an annual effective dose limit of 50 mSv.

Exceptional radiation sources must always be marked conspicuously.

Classification of areas at the Loviisa nuclear power plant

The classification of areas at the Loviisa nuclear power plant is based on the values in the regulations, adding three colours:

Quantity (unit)		**Green area**	**Orange area**	**Red area**
Dose rate (mSv/h)		0.025	1.00	
Airborne radioactivity (DAC)		0.30	30	
Surface contamination (Bq/cm^2)	β / γ	4	40	
	α	0.4	4	

3.1.2. Supervised areas

An area is defined as supervised if:
- the annual effective dose may exceed 1 mSv at certain places, or
- the annual equivalent dose to the eye lens may exceed 15 mSv, or
- the annual equivalent dose to the hands, feet and skin may exceed 50 mSv.

YVL 7.9 § 5.2 Area and zone division based on radiation conditions at the faculty - Supervised area

If the effective dose may exceed 1 mSv in a certain area, the equivalent dose to an eye 15 mSv or the equivalent dose to hands, feet or skin 50 mSv per year, the area shall be defined at least as a supervised area.
Working conditions in the supervised area and, when necessary, individual exposure shall be monitored according to the nature and extent of radiation exposure. Radiation sources in the area and the associated radiological danger shall be appropriately marked. The markings shall, if necessary, indicate that the area is a supervised area.
Workers shall be provided with instructions on working in the supervised area, use of radiation sources and radiological danger associated with the sources. Radiological conditions of the supervised area, outlines of the area and adequacy of the protective measures shall be verified with regular inspections.[10]

3.2. Access to controlled or supervised areas

Guide YVL 7.9 provides some information on movement of persons in controlled areas, including the need for access points to the various areas (except the lowest-risk zones) to be locked or at least monitored. It also stipulates that a "radiation work permit" must be issued for any work in controlled areas. This permit defines the work conditions and the obligations in terms of measurement of dose rate and airborne and surface contamination. Lastly, workers entering controlled areas must have received training on the radiation protection regulations, the fundamentals of radiation and radiological risks, the rules for working in controlled areas and the measurement techniques.

YVL 7.9 § 5.5 Movement in controlled area,
The access to the controlled area shall be monitored. Premises except those of the lowest zone shall be locked up or monitored

At least protective overalls and shoe covers shall be used as protective clothing, complemented by necessary additional protective gear (protective gloves and shoes, respirators) required in the task. Protective overalls may be replaced by protective coats in justified exceptions if the contamination risk of clothes is low.

§6 Radiation work permit
A radiation work permit is needed for radiation work conducted in the controlled area. A permanent permit may be issued for routine and repetitive tasks. The methods and responsibilities for issuing of the radiation work permit shall be defined in the radiation protection procedures of the facility.
The radiation work permit or related documents shall include at least
- author and acceptor of the permit
- date of granting
- names of workers (or supervisor and headcount)
- task and radiation conditions in the workplace
- job description
- requirements concerning measurement of dose rate, surface contamination and airborne activity
- work-specific dose monitoring
- safety instructions and protective equipment.

§7 Radiation protection training
According to the Radiation Act, workers shall be provided with training and instructions for their duties taking into account the features of work and conditions at the workplace.

Training provided to personnel working in the controlled area shall at least include the applicable parts of the radiation legislation and regulations issued by virtue of it, fundamentals of radiation and radiological risks, instructions for working in the controlled area as well as information on the monitoring of radiation exposure.

4. RULES IN THE MEDICAL SECTOR

4.1. Delineation of controlled areas

4.1.1. Radiotherapy

Regulatory guide ST 2.2 only covers radiotherapy equipment and treatment rooms. *Radiotherapy treatment rooms where radiotherapy equipment is used shall be classified as controlled areas must be designated as controlled areas. Rooms adjacent to treatment rooms where regular work is carried out shall in general be designated as supervised areas (refer to Guide 1.6 for further details on area designation). (ST2.2 §2)*

Shielding installed around rooms must be designed so that the dose limits are complied with.

For implementation of the optimisation principle, the following dose constraints are to be complied with:

- 6 mSv per year in rooms adjacent to the treatment rooms, designated as supervised areas,
- 0.3 mSv per year in adjacent rooms, not designated as supervised areas, to which unauthorised persons have unrestricted access.

ST 2.2 § 2 General Protection Principles

Shielding of the rooms adjacent to the treatment room shall be designed and constructed in such a way that the dose limits laid down in Amendment 1143/1998 to the Radiation Decree (1512/1991) are not exceeded under any circumstances. For the purpose of implementing the principle of optimization and taking into account the exposure from the different radiation sources, the design of the shielding shall be based on the dose constraints referred to in section 7 of the Radiation Decree. The dose constraints (effective doses) used in radiotherapy are:
• 6 mSv a year in rooms adjacent to the treatment room, defined as supervised areas
• 0.3 mSv a year in rooms outside the radiotherapy treatment rooms, not classified as supervised areas, to which unauthorized persons have unrestricted access. [4]

Planning limits based on weekly dose rates derived from the dose constraints are, in general, used when designing the construction of the treatment room. These planning limits are:
• supervised area: 120 µSv/week
• other area: 6 µSv/week.

In addition, the constructions shall be designed in such a way that the instantaneous dose rate in the rooms adjacent to the treatment room does not exceed 20 µSv/h in areas where people stay or work regularly. (ST2.2 §3.3.1)

4.1.2. Mammography

Regulatory guide ST 3.2 covering the use of mammography equipment stipulates that *if more than 4000 examinations are performed annually using a mammography equipment, then the immediate surroundings of the said equipment are to be designated as a supervised area. No such classification need be made if fewer than this number of exposures occur annually. (ST3.2 §3)*

4.2. Area designation examples

These examples are given in Appendix B of guide ST 1.6.

- Fixed X-ray equipment: *The controlled area in a room in which fixed x-ray equipment is used shall consist of that area next to the patient which, during irradiation, is exposed to primary*

radiation or radiation scattered directly from the patient. The rest of the use area may be classified as supervised, and the control room may be unclassified. If the control room is only partly shielded or open at the top or sides, it may be classified as supervised

- Fixed fluoroscopy equipment: *A room in which fluoroscopy equipment is used shall be classified as a controlled area during irradiation. In interventional radiography, for example, the control room shall also be classified as a controlled area if the control devices are located in a partly shielded space or in a space which is open at the top or sides.*

- Transportable X-ray equipment and transportable fluoroscopy equipment: *The controlled area shall, during irradiation, consist of that area next to the patient which is exposed to primary radiation or radiation scattered directly from the patient*

- Dental x-ray practices: *The controlled area shall, during irradiation, consist of that area next to the patient which is exposed to primary radiation or radiation scattered directly from the patient.*

- Radiotherapy: *In radiotherapy, controlled areas shall consist of the room used for radiotherapy and those adjacent utility rooms the occupancy in which requires special protection. The control room for radiotherapy equipment shall be classified as a supervised area.*

- Radionuclide therapy: *Rooms used for the isolation of patients who have been subject to radionuclide therapy (in particular treatment with 131I) shall, in general, be classified as controlled areas.*

- Veterinary x-ray practices: *The controlled area shall, during irradiation, consist of that area next to the animal which is exposed to primary radiation or radiation scattered directly from the animal.*

- Use of accelerators and irradiation equipment: *Irradiation and accelerator rooms shall be classified as controlled areas. Adjacent, shielded control rooms shall be classified as supervised areas.*

- Radionuclide laboratories: *Laboratories of types A and B as well as storages of radionuclides and radioactive wastes shall be classified as controlled areas. In type C laboratories, those laboratory rooms should be classified as controlled areas in which the risk of contamination is great or the activity handled at one time exceeds the activity limits presented in "Use of Unsealed Sources" in Appendix C. Other type C laboratories shall be classified as supervised area .*[5]

- Other places where radiation is used: *Laboratory rooms in which x-ray analyzers or equipment containing sealed sources are used shall usually be classified as supervised areas. If the primary beam of the x-ray equipment can be directed outside of the appliance, the area next to the beam shall be classified as a controlled area.*

- Sealed sources: *Storage rooms for sealed sources or for equipment containing sealed sources shall be classified as controlled or supervised areas according to the number and type of the sources. Radiation sources shall be in their shieldings and the storage room shall be locked.*

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5 Laboratories using radionuclides are classified as type C, B and A laboratories according to the activity handled at any one time. Type C laboratories are those where the maximum activity handled is 10 times the exemption value. Type B laboratories are those where the maximum activity handled is 10^4 times the exemption value. Type C laboratories are those where the activity handled is greater than 10^4 times the exemption value. [9]

4.3. Area marking: case of radiotherapy

At the door outside the treatment room there must be a sign warning of ionizing radiation intended in Guide ST 1.3, and a sign indicating that the room is used for radiotherapy (ST2.2 § 4.1)

The radiation head of a gamma beam therapy unit and the source container of an afterloading unit must be equipped with a sign warning of radiation and a sign indicating the activity of the source at any given time. In addition, the container shall bear a sign indicating the radionuclide that it contains. If the radiotherapy equipment incorporates other continuously radiating components with a surface dose rate exceeding 20 µSv/h, a sign warning of radiation, as specified above, must be attached to these components. (ST2.2 § 4.1)

There must be two warning lights outside the treatment room, in the immediate vicinity of the door to the treatment room:
1. White or yellow light indicating when the equipment is on and ready for operation. Text recommended for the light: "EQUIPMENT IN USE".
2. Red light indicating when the equipment is emitting radiation (...). Text recommended for the light: "NO ADMITTANCE". (ST2.2 § 4.1)

Inside the treatment room, a red signal light or an acoustic signal shall indicate when the equipment is emitting radiation. For gamma beam therapy equipment and afterloading equipment, this light shall be connected to a continuously operating dose rate monitor (see chapter 5), such that it is independent of the control system of the therapy equipment. (ST2.2 § 4.1)

The control console of the treatment unit must clearly indicate the operating status of the unit at any given time (e.g. type of radiation, energy, switching on/off, irradiation, and the position of the sources). (ST2.2 § 4.1)

5. INDUSTRIAL RADIOGRAPHY RULES

5.1. Area delineation in industrial radiography

Guide ST 5.6 [8]defines two types of installation for which specific areas must be designated:

- enclosed installations
- open installations.

5.1.1. Enclosed installations

Enclosed installation means that the radiography device has been placed in a shielded enclosure that only authorised personnel can enter. The radiography device is controlled from outside the room. The shielded enclosure is a controlled area. (ST 5.6 §5.3)

The dose rate at a distance of one metre from the walls outside the shielded enclosure must be lower than 7.5 µSv/h when the X-ray device is operated at its maximum allowable parameters, or when the highest allowable activity is used in the gamma radiography device. (ST 5.6 §5.3)

5.1.2. Open installations

5.1.2.1. Controlled areas

The area around the object to be radiographed where the dose rate exceeds 60 µSv/h shall be isolated as a controlled area (ST 5.6 §5.2)

5.1.2.2. Supervised areas

In addition to the controlled area, supervision shall be extended to an area where the dose rate is higher than 7.5 µSv/h (supervised area) . Only members of the radiography team can stay or work in this area during exposure. However, brief visits, such as during transit, are allowed. (ST 5.6 §5.2)

The dose rate shall be restricted to as low a level as possible in the area where the radiographers are working, and shall not as a rule exceed the value of 20 µSv/h. (ST 5.6 §5.2)

5.2. Area marking

5.2.1. Enclosed installation

The shielded enclosure shall be marked with a radiation warning sign. On the outside, there shall be a clearly visible warning light that is lit during exposure. The light must be accompanied with an explanatory text; e.g. "Red light is on during exposure". (ST 5.6 §5.2)

5.2.2. Open installation

Warning signs, ropes or other barriers shall be used for isolation purposes. When necessary, there shall also be a separate flashing signal lamp mounted on the X-ray device. The controlled area, and access to it, must be controlled for the whole duration of the exposure. If the exposure takes place in an open field, and it can be effectively controlled, the area does not need to be isolated. (ST 5.6 §5.2)

6. RULES IN FACILITIES USING X-RAYS

Guide ST 3.6 covers all facilities using X-rays in the medical, veterinary, research, education and industry sectors.

It stipulates that *the shielding of an X-ray room must be designed and constructed so that the dose limits* (general public dose limit) *prescribed in the Radiation Decree are not exceeded in the premises surrounding the room under any circumstances. The dose constraint when using X-ray devices shall be 0.3 mSv per year. (ST3.6, §2.1.*

7. REFERENCES

[1] Radiation Act 27.3.1991 Amendments up to and including 624/2011.

[2] Guide ST 1.3 Warning signs for radiation sources 16 May 2006

[3] Guide ST 1.6 Operational radiation safety 10 December 2009

[4] Guide ST 2.2 Radiation safety of radiotherapy equipment and treatment rooms 2 February 2001

[5] Guide ST 3.2 Mammography equipment and their use 17 August 2001

[6] Guide ST 3.6 Radiation safety in X-ray facilities 24 September 2001

[7] Guide ST 5.1 Radiation safety of sealed sources and devices containing them 7 November 2007

[8] Guide ST 5.6 Radiation safety in industrial radiography 17 February 1999

[9] Guide ST 6.1 Radiation safety when using unsealed sources 17 March 2008

[10] Guide YVL 7.9 Radiation protection of workers at nuclear facilities 21 January 2002

COUNTRY SHEET – UNITED-KINGDOM

CONTENTS

1. INTRODUCTION

In the United Kingdom, the specific requirements for protection of workers and the population against ionising radiation are given in the Ionising Radiations Regulations 1999 (IRR99) [1]. To facilitate practical implementation of IRR99, the Health and Safety Executive (HSE), the British authority responsible for radiation protection, has published an application guide, the Approved Code of Practice (ACOP) and guidance, which provides a detailed analysis and explanation of each of the IRR99 regulations [2].

The main aim of the IRR99 regulations is to establish a framework for ensuring that exposure of workers and the public to ionising radiation is as low as reasonably practicable (ALARP) and does not exceed the regulatory limits. Part of IRR99 is devoted exclusively to the definition of controlled areas and supervised areas; it is divided into four sub-parts:

- designation of controlled and supervised areas: designation criteria and method
- local rules and RP supervisors: for each controlled or supervised area, an employer must define local rules appropriate for the radiological risk and the nature of any operations performed in the area
- additional requirements for supervised and controlled areas: access procedures and conditions, marking, etc.
- monitoring of supervised and controlled areas.

For the nuclear industry, HSE has published nuclear facility Safety Assessment Principles (SAPs) for nuclear installation inspectors to provide them with guidance in their inspection work [3]. The SAPs describe the good practices to be implemented from the point of view of the Nuclear Installations Inspectorate (NII), part of the HSE. It is important to note that the SAPs are available for information to the licensees, so that they know the points on which they may be judged, but have no statutory basis. To support the SAPs, HSE has also published several Technical Assessment Guides (TAG) providing more operational details of the various principles, while remaining fairly general. Like the SAPs, the TAGs are intended for the inspectors to guide them in their work. The principal TAG giving instructions for the designation of areas is TAG38, covering radiological protection [4].

The description in this document of practical application in the nuclear sector is based on the British Energy radiological safety rules, which put into effect the undertakings given by this operator to the authority on the practical implementation of the radiation protection regulations. The British Energy radiological safety rules are general rules defining the radiation protection policy of the company and clarifying its practical implementation. Each of these rules is covered by a specific document, a Company Radiological Safety Instruction (CRSI). Two CRSIs cover more specifically the definition of controlled and supervised areas and the organisation of work in these areas [5]:

- CRSI 2: *Designation of controlled and supervised areas*
- CRSI 10*: Entry to and work in supervised and controlled areas*.

Although CRSI 2 is the basis, some details for specific cases are found in the following two documents:

- CRSI 9: *Transport and movement of radioactive substances*
- CRSI 11: *Radiography and the use of ionising radiation for calibration, testing and inspection*

In the medical sector, a guide to good practice in radiation protection in the clinical environment for the medical and dental sectors [6] was produced jointly by the Institute of Physics and Engineering in

Medicine, the National Radiological Protection Board[6] (NRPB) and the Health and Safety Executive (HSE) in 2002. It clarifies the IRR99 regulations, including area delineation criteria and delineation characteristics, conditions of access to these specific areas, and the specific aspects for mobile systems (radiography equipment).

2. DESIGNATION OF REGULATED RADIATION AREAS IN THE GENERAL REGULATIONS

2.1. Purpose and principle

The UK regulations stipulate that the aim of the IRR99 and the associated code of practice (ACOP) is to establish a framework for ensuring that occupational exposure to ionising radiation is kept as low as reasonably practicable (ALARP) and does not exceed the specified dose limits.

In addition, in the definition of the controlled area, it is stipulated that designation as a controlled area is necessary for any area in which special procedures must be followed to restrict significant exposures or to limit the risk and magnitude of accidents.

The code of practice also stipulates that the main purpose of designating controlled areas is to help ensure that the measures taken to avoid accidents and to implement the ALARP principle are effective. Controlled areas allow verification of who can enter or work in these areas and of which special procedures are to be followed.

Supervised areas are designated for example where there is a potential risk of change in the radiological conditions that might necessitate their designation as controlled areas.

Introduction of IRR 99
The main aim of the Regulations and the supporting Approved Code of Practice (ACOP) is to establish a framework for ensuring that exposure to ionising radiation arising from work activities, is kept as low as reasonably practicable and does not exceed dose limits specified for individuals. This applies to exposure, whether from man-made or natural radiation and from external radiation (eg X-ray set) or internal radiation (eg inhalation of a radioactive substance).

IRR99 – Regulation 16 – Designation of controlled or supervised areas
(1) Every employer shall designate as a controlled area any area under his control which has been identified by an assessment made by him (whether pursuant to regulation 7 or otherwise) as an area in which -

(a) it is necessary for any person who enters or works in the area to follow special procedures designed to restrict significant exposure to ionising radiation in that area or prevent or limit the probability and magnitude of radiation accidents or their effects; or

(b) any person working in the area is likely to receive an effective dose greater that 6mSv a year or an equivalent dose greater than three-tenths of any relevant dose limit referred to in Schedule 4 in respect of an employee aged 18 years or above.

(3) An employer shall designate as a supervised area any area under his control, not being an area designated as a controlled area -

(a) where it is necessary to keep the conditions of the area under review to determine whether the area should be designated as a controlled area; or

(b) in which any person is likely to receive an effective dose greater than 1mSv a year or an equivalent dose greater than one-tenth of any relevant dose limit referred to in Schedule 4 in respect of an employee aged 18 years or above.

[6] The National Radiological Protection Board (NRPB) became a Division of Health Protection Agency (HPA) in 20005 and subsequently part of Public Health England (PHE) in 2013.

ACOP – Regulation 16(1) – Purpose of designating controlled areas (§252)
252 The main purpose of designating controlled areas is to help ensure that the measures provided under regulations 7(3) and 8(1) are effective in preventing or restricting routine and potential exposures. This is achieved by controlling who can enter or work in such areas and under what conditions. Normally, controlled areas will be designated because the employer has recognised the need for people entering the area to follow special procedures. Such procedures could take the form of a detailed system of work which sets out how the tasks should be undertaken in a way that restricts significant exposure.

ACOP – Regulation 16(3)
269 The decision to designate an area as a supervised area depends both on the assessment of likely doses in that area and the probability that conditions might change. For example, an area may need to be kept under review and therefore designated as a supervised area because of the possibility that radioactive contamination might spread.

2.2. Types of facility covered by the IRR99 regulations

IRR99 refers to all types of facility and all sectors of activity.

IRR 99- Regulation 3 Application
(1) Subject to the provisions of this regulation and to regulation 6(1), these Regulations shall apply to -
(a) any practice;
(b) any work (other than a practice) carried out in an atmosphere containing radon 222 gas at a concentration in air, averaged over any 24 hour period, exceeding 400 Bq m-3 except where the concentration of the short-lived daughters of radon 222 in air averaged over any 8 hour working period does not exceed 6.24 x 10-7 Jm-3; and
(c) any work (other than work referred to in sub-paragraphs (a) and (b) above) with any radioactive substance containing naturally occurring radionuclides.

IRR 99 – Regulation 2 – Interpretation
"practice" means work involving -
(a) the production, processing, handling, use, holding, storage, transport or disposal of radioactive substances; or
(b) the operation of any electrical equipment emitting ionising radiation and containing components operating at a potential difference of more than 5kV,which can increase the exposure of individuals to radiation from an artificial source, or from a radioactive substance containing naturally occurring radionuclides which are processed for their radioactive, fissile or fertile properties;

2.3. Assessment of the nature and magnitude of the risk before designation

Any new activity involving work with radiation must undergo prior risk assessment to identify the measures to be taken to limit exposures. This assessment is the responsibility of the employer (IRR99 Regulation 7). This assessment is conducted in consultation with the radiation protection adviser. It must include assessment of whether designation of a supervised or controlled area is necessary.

In addition, the code of practice states that the risk assessment for designation of controlled areas must take account of the following factors (*ACOP - Regulation 16 - § 256)*:
(a) which people are likely to need access to the area;
(b) the level of supervision required;
(c) the nature of the radiation sources in use and the extent of the work in the area;
(d) the likely external dose rates to which anyone can be exposed;
(e) the likely periods of exposure to external radiation;
(f) the physical control methods already in place, such as permanent shielding and ventilated enclosures;
(g) the importance of following a procedure closely in order to avoid receiving significant exposure;

(h) the likelihood of contamination arising and being spread unless strict procedures are closely followed;
(i) the need to wear personal protective equipment in that area; and
(j) maximum doses estimated for work in the area.

Written local rules should identify the key working instructions intended to restrict any exposure in that controlled or supervised area (*ACOP - Regulation 17 - § 256).*

IRR 99 Regulation 7 – prior risk assessment
(1) Before a radiation employer commences a new activity involving work with ionising radiation in respect of which no risk assessment has been made by him, he shall make a suitable and sufficient assessment of the risk to any employee and other person for the purpose of identifying the measures he needs to take to restrict the exposure of that employee or other person to ionising radiation.

(2) Without prejudice to paragraph (1), a radiation employer shall not carry out work with ionising radiation unless he has made an assessment sufficient to demonstrate that -
(a) all hazards with the potential to cause a radiation accident have been identified; and
(b) the nature and magnitude of the risks to employees and other persons arising from those hazards have been evaluated.

(3) Where the assessment made for the purposes of this regulation shows that a radiation risk to employees or other persons exists from an identifiable radiation accident, the radiation employer shall take all reasonably practicable steps to
(a) prevent any such accident;
(b) limit the consequences of any such accident which does occur; and
(c) provide employees with the information, instruction and training, and with the equipment necessary, to restrict their exposure to ionising radiation.

2.4. Area types

2.4.1. Controlled area

In the IRR99 regulations (Regulation 16(1)), a controlled area shall be designated if it is judged that special procedures are necessary to restrict the exposure of persons present or working in the area, or if a worker in the area is likely to receive an effective dose greater than 6 mSv a year or an equivalent dose greater than three-tenths of any prescribed equivalent dose limits:

- for the hands, forearms, feet and ankles: an equivalent dose greater than 150 mSv in a calendar year,
- for the skin: an equivalent dose greater than 150 mSv in a calendar year (applied to the dose averaged over any area of 1 cm^2 regardless of the area exposed),
- for the eye lens: an equivalent dose greater than 45 mSv in a calendar year.

In addition, the code of practice stipulates that special procedures should always be put in place to avoid significant exposure (248). Designation of an area as a controlled area is recommended if:

- the external dose rate is greater than 7.5 μSv per hour when averaged over a working day,
- the hands of a worker can enter an area where the average dose rate exceeds 75 μSv per hour over eight working hours,
- there is a significant risk of spreading radioactive contamination outside the working area,
- employees are liable to work in the area for a period sufficient to receive an effective dose in excess of 6 mSv/year.

The code of practice (249) also recommends that an area be designated as a controlled area if the dose rate (averaged over a minute) exceeds 7.5 μSv per hour and:

- the work being done is site radiography (i.e. any radiography of an object other than that carried out in an enclosure or cabinet that restricts the dose rate outside the enclosure to 7.5 μSv/h (averaged over a minute)),
- workers untrained in radiation protection are likely to enter the area.

A final recommendation (257) is to also designate an area as a controlled area if:

- it might be accessed by persons who are not normally exposed occupationally to radiation,
- the normal control measures must be suspended temporarily for work such as maintenance or source changing,
- persons are likely to be exposed to significant levels of surface or airborne contamination (greater than the DACs),
- respiratory protection equipment must be worn in the area.

The code of practice recommends that the main criterion for designation of a controlled area should not be based primarily on the expected annual dose, as this is often difficult to predict on the basis of dose rates in the areas (266). The code of practice states that the reasons for the difficulty of estimating the annual dose include the fact that dose rates are rarely constant over long time periods and within the physical barriers of the area boundaries, that there may be significant variations in the volume of work for persons, and that the duration of exposure of persons in the areas may be difficult to estimate. However, it is recommended that controlled area designation be considered for any area where the external dose rate routinely exceeds 3 μSv/h and where workers are present for about 2000 hours a year. The workers would then be likely to exceed 6 mSv/year.

IRR99 - Regulation 16 Designation of controlled or supervised areas
(1) Every employer shall designate as a controlled area any area under his control which has been identified by an assessment made by him (whether pursuant to regulation 7 or otherwise) as an area in which -

(a) it is necessary for any person who enters or works in the area to follow special procedures designed to restrict significant exposure to ionising radiation in that area or prevent or limit the probability and magnitude of radiation accidents or their effects; or

(b) any person working in the area is likely to receive an effective dose greater that 6 mSv a year or an equivalent dose greater than three-tenths of any relevant dose limit referred to in Schedule 4 in respect of an employee aged 18 years or above.

ACOP - Regulation 16, § 248
248. Special procedures should always be necessary to restrict the possibility of significant exposure, and therefore employers should designate controlled areas, in cases where:
(a) the external dose rate in the area exceeds 7.5 microsieverts per hour when averaged over the working day;
(b) the hands of an employee can enter an area and the 8-hour time average dose rate in that area exceeds 75 microsieverts per hour;
(c) there is a significant risk of spreading radioactive contamination outside the working area;
(d) it is necessary to prevent, or closely supervise, access to the area by employees who are unconnected with the work with ionising radiation while that work is under way; or
(e) employees are liable to work in the area for a period sufficient to receive an effective dose in excess of 6 millisieverts a year.

ACOP - Regulation 16, § 249
In addition, an area should be designated as a controlled area if the dose rate (averaged over a minute) exceeds 7.5 microsieverts per hour and:
(a) the work being undertaken is site radiography; or
(b) employees untrained in radiation protection are likely to enter that area, unless the only work with ionising radiation involves a radioactive substance dispersed in a human body and none of the conditions in the previous paragraph apply.
In this context, site radiography means any radiography of inanimate objects other than that which is carried out in an enclosure or cabinet that restricts the dose rate (averaged over a minute) outside the enclosure to 7.5 microsieverts per hour.

ACOP - Regulation 16, § 257
In addition to the circumstances describes in § 248 and 249, the employer may find it necessary to designate an area as controlled if:
(a) access is foreseeable to that area by people, such as office staff, whose work does not normally involve ionising radiation (see ACOP advice in paragraph 60);
(b) normal control measures for an area have to be suspended for work such as maintenance or source changing;
(c) people are likely to be exposed to significant levels of surface or airborne contamination in the area, in excess of appropriate derived working levels or derived air concentrations;
(d) respiratory protective equipment must be worn while working in the area.

ACOP - Regulation 16, § 266 :
In practice, it is often difficult to predict annual doses received by employees from knowledge of dose rates in working areas, because:
(a) dose rates are seldom constant over long time periods and within the physical boundaries of areas;
(b) there are significant variations in the pattern of work for individuals; and
(c) the duration of an individual's exposure in the areas may be difficult to estimate.
Consequently, the expected annual dose is not likely to be the main criterion in most cases for deciding whether an area needs to be designated as a controlled area. One exception might be areas in radon-affected workplaces where high radon levels are known to occur and no special procedures need to be followed by employees. Also, where employees work for about 2000 hours a year in an area where the external dose rate routinely exceeds 3 microsieverts per hour, that area may need to be designated as a controlled area because that individual would be likely to receive a dose greater than 6 millisieverts a year.

The code of practice also defines cases in which area designation is not necessary (258 to 260):
- the work is a routine activity for which special precautions are not required,
- the work is carried out under conditions of low levels of radioactivity and radiotoxicity in ventilated enclosures or on a laboratory bench and only routine precautions are expected (…),
- places that cannot be accessed physically,
- if the only person exposed in the area is a person undergoing medical examination or treatment.

ACOP - Regulation 16 - §258-259-260 :

258. A controlled area would not normally be required where:
(a) work is routine and special precautions are not required, for example work in the vicinity of a fixed radiation gauge (except maintenance work); or
(b) work is carried out with low levels of radionuclides of low radiotoxicity inside efficiently ventilated enclosures (eg fume cupboards) or on a laboratory bench and only routine precautions are expected, such as the use of lined trays to contain spillage and the use of disposable protective gloves.

259 Places which cannot physically be entered do not need to be designated. It is not necessary to designate an area as a controlled area if it is not reasonably foreseeable that a person, or part of a person, will enter or be present in that area.

260. Designation of an area is not required if the only person in that area who is exposed to ionising radiation will be a person undergoing medical examination or treatment (see regulation 3(3)). However, the employer needs to consider the possibility of exposures, including accidental or unintended exposures, of other members of the public and members of staff (see also paragraphs 550-553 concerning potential exposures resulting from defects or malfunctions in equipment used for medical exposures).

2.4.2. Supervised area

An employer shall designate as a supervised area *any area under his control, not being an area designated as a controlled area :*
(a) where it is necessary to keep the conditions of the area under review to determine whether the area should be designated as a controlled area; or
(b) in which any person is likely to receive an effective dose greater that 1 mSv a year or an equivalent dose greater than one-tenth of any relevant dose limit referred to in Schedule 4 in respect of an employee aged 18 years or above.) (*IRR99 - Regulation 16(3))*:

- for the hands, forearms, feet and ankles: an equivalent dose greater than 50 mSv in a calendar year
- for the skin: an equivalent dose greater than 50 mSv in a calendar year (applied to the dose averaged over any area of 1 cm^2 regardless of the exposed area)
- for the eye lens: an equivalent dose greater than 15 mSv in a calendar year.

The code of practice also stipulates that it is not necessary to have a supervised area outside every controlled area *(ACOP – Regulation 16(3) §269 et 270)*.

ACOP – Regulation 16(3) §269 et 270
269 The decision to designate an area as a supervised area depends both on the assessment of likely doses in that area and the probability that conditions might change. For example, an area may need to be kept under review and therefore designated as a supervised area because of the possibility that radioactive contamination might spread. However, it will not be necessary to designate a supervised area outside every controlled area. For example, if a controlled area has been designated on the basis of external dose rate, and conditions in adjacent areas are unlikely to alter significantly, a supervised area will not be necessary unless a person is likely to receive a dose in excess of 1 millisievert a year in those adjacent areas.

270 In laboratories where only small quantities of unsealed radioactive substances are used, it may not be appropriate to designate the whole room as a controlled area to ensure that specific procedures are followed by those who enter or work there. In such a laboratory, however, there will be general arrangements for preventing spillages as far as possible and for cleaning up any contamination arising from a foreseeable spillage. Normally, the employer should designate at least part of the laboratory as a supervised area if contamination could build up over a period of some weeks as a result of not following these arrangements.

2.5. Procedure for temporary de-designation of a controlled area

If the periods during which work with ionising radiation takes place are clearly defined, follow a regular pattern, or are only intermittent, the employer may wish to de-designate on a regular basis, for example to allow cleaners to have routine access where this would be appropriate. This may be done provided sufficient steps are taken to remove the need for designation of the area, for example any X-ray generator is isolated from the power supply or any radioactive substances are removed or otherwise made safe. These steps will need to be summarised in local rules. (ACOP - Regulation 16, § 263)

2.6. Procedure for temporary designation of an area as a controlled area

The employer has the option of designating an area temporarily as a controlled area in order to carry out a particular activity (maintenance, for example). An employer may decide that it is unnecessary to designate an area as a controlled area permanently because access to it is usually not possible and physical safeguards prevent any accidental exposure. Temporary designation can allow workers to enter the area if necessary under exceptional circumstances.

ACOP - Regulation 16, § 264

An employer may decide it is unnecessary to designate an area as a controlled area because employees do not enter that area and physical safeguards prevent accidental exposures. However, if contractors have to enter the area for particular tasks, such as maintenance, it may be necessary to designate such areas temporarily under specified conditions.

2.7. Controlled area boundary characteristics

Controlled areas must be physically demarcated (or delineated by some other method: refer to marking). This demarcation must be sufficient to avoid any unauthorised entry into the area. It may involve the use of existing features such as walls and doors, or the use of temporary barriers which will need to be checked regularly.

IRR99 - Regulation 18 Additional requirements for designated areas
(1) Every employer who designates any area as a controlled or supervised area shall ensure that any such designated area is adequately described in local rules and that -
(a) in the case of any controlled area -
(i) the area is physically demarcated or, where this is not reasonably practicable, delineated by some other suitable means; and
(ii) suitable and sufficient signs are displayed in suitable positions indicating that the area is a controlled area, the nature of the radiation sources in that area and the risks arising from such sources; and
(b) in the case of any supervised area, suitable and sufficient signs giving warning of the supervised area are displayed, where appropriate, in suitable positions indicating the nature of the radiation sources and the risks arising from such sources.

ACOP Regulation 18 (§ 298- 300)

298. Designated areas will usually be described by reference to fixed features such as walls. Where the source of ionising radiation is mobile, the area(s) may be described generically, for example by reference to distances from the source or, if necessary, to distances from other objects irradiated by the source.

299. The main purpose of physically demarcating a controlled area is to help restrict unauthorised access. In determining whether suitable means of restricting access have been provided, the employer should consider the nature of the work and the likelihood that the means provided will restrict access to those people who are permitted to enter the area. To be effective, the method of demarcation should clearly indicate the extent of the controlled area, with no possibility for doubt.

300. In most cases it will be appropriate to use physical features, for example existing walls and doors. Employers should provide temporary barriers where these physical features cannot be used; these barriers will usually need to be supervised. In such cases, the areas must be clearly delineated by other suitable means so employees (and other people as necessary) are aware that these areas exist.

It may not be possible to demarcate a controlled area; in such cases, either appropriate marking must be used or, in the case where work in a controlled area is of short duration, the extension of the designated area must be written into the local rules and continuous supervision is necessary to restrict access.

ACOP Regulation 18 § 301

301. Examples of situations where it may not be reasonably practicable to demarcate a controlled area are when:
(a) a vehicle transporting a radioactive substance is stationary at the side of a road because of breakdown and there is free-flowing traffic along the road;
(b) the area is an upper room of a multi-storey building and extends outside a window to which there is no access - the area would only be demarcated inside the building;

(c) a person has been administered with a radioactive substance as part of a medical exposure and is subsequently located in part of a room where the whole of that room has not been designated. Suitable means for delineation in this case would be a description, kept in a convenient place, of the extent of the controlled area around that patient; or
(d) the conditions requiring a controlled area arise from the use of X-ray equipment for dental radiography or veterinary radiography. The operator should be able to see any person in the vicinity of the controlled area and quickly de-energise the X-ray equipment from the normal operating position

2.8. Controlled area access conditions

IRR 99 stipulates that the persons authorised to access controlled areas are:

- classified personnel, other than outside workers
- outside workers, classified, the employer having previously ensured that the persons:
  - are subject to individual dose assessment
  - have been provided with and trained to use personal protective equipment
  - have received radiation protection training
  - are fit for work with ionising radiation
- non-classified persons who enter or remain in the controlled area with written authorisation (but the cumulative dose per person in a calendar year must be less than the dose requiring designation as a classified person, and less than the dose limit).

The code of practice also stipulates that restriction of entry into a controlled area does not apply to patients or research subjects for the purpose of receiving a medical exposure. However, the hospital may provide written authorisation to persons accompanying the patients.

IRR 99 - Regulation 18 (2)
The employer who has designated an area as a controlled area shall not permit any employee or other person to enter or remain in a such an area unless that employee or other person -
a) being a person other than an outside worker, is a classified person;
b) being an outside worker, is a classified person in respect of whom the employer has taken all reasonable steps to ensure that the person –
1) is subject to individual dose assessment pursuant to regulation 21;
2) has been provided with and has been trained to use any personal protective equipment that may be necessary
3) has received any specific training required
4) has been certified fit for the work with ionising radiation which he is to carry or,
c) not being a classified person, enters or remains in the area in accordance with suitable written arrangements for the purpose of ensuring that
1) in the case of an employee aged 18 years or over, he does not receive in any calendar year a cumulative dose of ionising radiation which would require that employee to be designated as a classified person; or
2) in the case of any other person, he does not receive in any calendar year a dose of ionising radiation exceeding any relevant dose limit.

ACOP - Regulation 18, § 318
A hospital may have to provide written arrangements to enable comforters and carers to enter a room designated as a controlled area in support of relative or friend who has received an administration of a radiopharmaceutical or a therapeutic purpose

2.9. Specific measures to limit the contamination risk

The United Kingdom regulations require specific measures to prevent the spread of contamination. The employer is required to provide suitable and sufficient washing and changing facilities for persons who enter or leave any controlled or supervised area. These facilities must be maintained.

IRR 99 - Regulation 18 (6) et (7)
(6) In any case where there is a significant risk of the spread of radioactive contamination from a controlled area, the employer who has designated that area as a controlled area shall make adequate arrangements to restrict, so far as is reasonably practicable, the spread of such contamination.

(7) Without prejudice to the generality of paragraph (6), the arrangements required by that paragraph shall, where appropriate, include -
(a) the provision of suitable and sufficient washing and changing facilities for persons who enter or leave any controlled or supervised area;
(b) the proper maintenance of such washing and changing facilities;
(c) the prohibition of eating, drinking or smoking or similar activity likely to result in the ingestion of a radioactive substance by any employee in a controlled area; and
(d) the means for monitoring for contamination any person, article or goods leaving a controlled area.

2.10. Area marking

Suitable warning signs should be installed at each area entrance (IRR99 reg 18(1) cited above). These signs enable employees who have received appropriate training or instruction to understand the risks and know exactly what action to take in order to enter the area (for example, the signs must indicate what type of personal protective equipment they must wear).

Warning signs must be installed at each entrance to controlled areas or, if the area is demarcated by temporary barriers, at frequent intervals.

If demarcation of controlled areas is not practicable, one or more persons must be designated to give verbal warning to anyone approaching the area.

Warning signs may be appropriate for some supervised areas, giving the nature of the radioactive sources and the related risks.

Where the extent of a supervised area is clearly set out in the local rules and is well understood by those who work there, it might not be necessary to install warning signs.

ACOP Regulation 18 §305 à 308
305. Suitable warning signs are required for each designated controlled area.(…) Suitable positions are likely to be at each entrance to the area or, in the case of temporary barriers, at frequent intervals where they can be seen by people approaching the barrier.

306. In addition, warning signs will be appropriate for some supervised areas. Where the extent of the supervised area is clearly set out in the local rules and the extent of the area is well understood by those who work there, it might not be appropriate to provide warning signs.

307. All warning signs should comply with the minimum requirements set out in Parts I-VII of Schedule 1 of the Health and Safety (Safety Signs and Signals) Regulations 1996. Employers may add any supplementary text or cautionary notice they wish to the pictogram to make the sign appropriate to their situation. Signs should give sufficient information to alert employees to the risks arising from the source (eg X-rays or risk of inhaling or ingesting radioactive contamination). This should enable employees who have received appropriate training or instruction to know what action to take on entering the area, for example to wear personal protective equipment.

308 If it is not reasonably practicable to demarcate a controlled area it may not be practicable to provide warning signs. If so, one or more people should be instructed to attend to give a suitable verbal warning to anyone approaching the boundary of the controlled area.

3. NUCLEAR FACILITY RULES

3.1. Recommendations to inspectors for area delineation in the nuclear sector

In the Safety Assessment Principles for nuclear installation inspectors and the technical guide on radiation protection (TAG 38), it is stated that supervised or controlled areas should be further divided, if necessary.

Among the six principles of radiation protection set out by the SAPs, principle RP3 states that "*Where appropriate, designated areas should be further divided, with associated controls, to restrict exposure and prevent the spread of radioactive substances*". The further division of designated areas should be based on the levels of radiation, contamination and airborne activity (485). These areas must have appropriate controls on access to the area, occupancy and use of personal protective equipment (486). Where doses of a significant fraction of any dose limit are likely to be received in a few minutes, access must be limited by physical measures such as padlocks or alarms (487). However, the SAPs do not give any quantitative data.

As far as the classification of areas is concerned, apart from the necessity to further divide controlled and supervised areas according to the radiological risks (radiation, contamination and airborne radioactivity), TAG 38 states that clear definition of zone categorisation and of the measurement and protection means appropriate for each zone is needed. In addition, the area classification should be an indication of the control means to be implemented and adapted, and should increase, e.g. C1, C2, C3, etc., and R1, R2, R3, etc., for increasing levels of contamination and radiation, respectively.

It is also states that control of access to the lower-risk zones may be sufficient through the installation of physical barriers and warning signs, whereas the controls for the higher-risk zones may require isolation through shielding and interlocking mechanisms. Furthermore, access to a low-risk zone must not necessitate transit through a zone that requires additional protection. The SAPs recommend the implementation of specific measures for zones in which a significant dose may be received in a few minutes (487). TAG 38 stipulates that a dose is significant when it exceeds one-tenth of any of the dose limits[7].

SAP principle RP4 concerns contaminated areas: "Appropriate provisions for protecting persons entering and working in contaminated areas should be provided."

The TAG states that the provisions for protecting persons entering and working in these areas must as far as possible be based on engineered means rather than on personal protective equipment.

The following examples are given: ventilation; use of shielding and increasing the distance from the source, for example by use of long tools; clearly marked evacuation routes from these areas; use of

[7] For example, for a whole body effective dose: 2 mSv.

containment; provision and use of change rooms and washing facilities. If these means do not provide full protection of the personnel, the use of personal protective equipment must be considered (gloves, overshoes, respirators, etc.).

SAP
RP3. Designated areas
Where appropriate, designated areas should be further divided, with associated controls, to restrict exposure and prevent the spread of radioactive substances.

485 The further division of designated areas should be based upon the levels of radiation, contamination and airborne activity, measured and/or expected as the result of particular planned work activities.

486 Each area should have appropriate controls on access and egress (including evacuation), occupancy and adequate arrangements for the use of personal protective equipment.

487 Where doses of a significant fraction of any statutory dose limit are likely to be incurred in a matter of minutes in any area, access should be controlled by physical means such as interlocks, alarms, or locked doors to prevent unauthorised entry. Prompt escape by any person from such places should not be obstructed. Where such control measures are not reasonably practicable, an equivalent standard of protection should be ensured by other arrangements.

RP4. Contaminated areas
Appropriate provisions for protecting persons entering and working in contaminated areas should be provided.

488 There should be provision for monitoring and controlling the spread of airborne activity and contamination within and beyond each area.

489 The level of contamination within such areas should be kept ALARP for the nature of the activities undertaken.

490 The facility should include the ventilation of contaminated areas to control potential airborne contamination, and appropriate features for limiting the spread of contamination. Where change barriers are used, they should be located taking into account the balance between protecting people and reducing the spread of radioactive contamination.

TAG 38
4.6 . RP.3 indicates the need for controls in various areas of the facility commensurate with the radiation hazards in those areas. The area design requirements and access controls should always aim to keep exposures ALARP. The zone category should be an indication of the required degree of engineered and managerial controls and should increase e.g. C1, C2, C3 etc and R1, R2, R3 etc for increasing levels of contamination and radiation respectively. The safety case should make clear the zone categorisation, or area classification system, and corresponding protection arrangements.

3.2. British Energy rules

Instruction CRSI 2 covers the designation of controlled and supervised areas. The principal elements are reproduced here.

Responsibility for the classification of areas lies with the location manager, and is delegated to the Accredited Health Physicist and to the Senior Authorised Person. British Energy defines two types of radiation areas: areas designated according to the external exposure risk (areas R1 to R4) and areas designated according to the surface or airborne contamination risk (areas C2 and C3).

3.2.1. Designation criteria with respect to the external exposure risk

Radiation controlled areas are designated on the basis of the dose rate (refer to Table 1). In some cases the use of a time-averaged dose rate over a period longer than one minute may be authorised by a radiation protection adviser.

Table 1. Limits of supervised and controlled areas at British Energy

	Minimum dose rate (µSv/h)	**Maximum dose rate (µSv/h)**
Radiation Supervised Area R1	0.5	3.0
Radiation Controlled Area R2	3.0	50.0
Radiation Controlled Area R3	50.0	500.0
Radiation Controlled Area R4	500.0	

Localised sources: If, due to a localised source, an area should be designated as R3 according to the above dose rate criteria, but the area would be restricted to a radius of 500 mm around the source, then the area may be designated as R2. The existence of a high local dose rate must be indicated locally by a sign. The same rule applies to an R3 area in which there is a source that should require designation of the area as R4.

In addition, the instruction covers two situations of transient dose rates relating to plant unit operation:

- *High Transient Dose Rate - An instantaneous dose rate, which exists in an Area due to the operation of plant or apparatus which, exceeds 100 mSv/h at 1m from the source of radiation.*
- *Very High Transient Dose Rate - An instantaneous dose rate, which exists in an Area due to the operation of plant or apparatus which, exceeds 600 mSv/h at 1m from the source of radiation.*

A controlled area R4 designated because it includes very high transient dose rates must be treated as a permanent controlled area R4. This area cannot be declassified unless effective devices[8] have been introduced to prevent the recurrence of the very high transient dose rates.

[8] An "effective device" is defined as *"an electrical and/or mechanical device which under specified conditions inhibits the operation of any plant or apparatus which could cause radiation and/or contamination levels to increase, and whose design is such that failure of the Effective Device prevents the plant or apparatus from being operated"*.

CRSI 2 – Appendix B Designation and demarcation of radiation supervised and controlled areas

B2.1 Radiation Supervised and Controlled Areas shall normally be designated when the dose rate exceeds, or may exceed, the values in Table B1. In some cases the use of a time averaged dose rate over a period longer than one minute may be used with agreement of a radiation protection adviser.

B2.6 In some circumstances it may be appropriate to designate an area even though the dose rates do not require such a designation. An example of this would be a large Radiation Controlled Area, which contains within it a number of lower dose rate areas. Because of the need to control access to the Radiation Controlled Areas, these lower dose rate areas maybe included in the Controlled Area. Similarly, it may be administratively convenient to enlarge a Controlled Area so that the boundaries correspond to physical features such as walls, rather than following a dose rate contour.

CRSI 2 – Appendix B Designation and demarcation of radiation supervised and controlled areas

B2.9 If, due to a localised source of radiation, an Area should be designated as a Radiation Controlled Area R3 in accordance with the definitions given in Table B1, but the Radiation Controlled Area R3 would not extend more than 500 mm from the surface of the source, an Accredited Health Physicist may designate the Area as a Radiation Controlled Area R2. If the area is given the lower designation, a sign of the type shown in figure B3 shall identify the existence of the local high dose rate.

B2.10 If, due to a localised source of radiation, an Area should be designated as a Radiation Controlled Area R4 in accordance with the definitions given in Table B1, but the Radiation Controlled Area R4 would not extend more than 500 mm from a surface of the source, an Accredited Health Physicist may designate the Area as a Radiation Controlled Area R3. If the Area is given the lower designation, the existence of the local high dose rate must be identified by means of a sign of the type shown in figure B3.

B3.2 Radiation Controlled Areas R4 designated because of Very High Transient Dose Rates shall be treated as permanent Radiation Controlled Areas R4. Such Areas shall not be declassified or reclassified as a lower category area unless Effective Devices have been introduced to prevent the recurrence of the Very High Transient Dose Rates.

CRSI 2 – 5. Definitions

Very High Radiation Area – An Area where the instantaneous dose rate exceeds 1 Sv/h at 0.5 metre.

3.2.2. Controlled area designation criteria for surface or airborne contamination

The controlled area designation criteria for surface contamination (C2 areas) is the level of loose contamination averaged over an area not exceeding 1000 cm^2 on the floor, walls or ceiling or 300 cm^2 in all other cases.

An area is designated as a contamination controlled area C2 if the values below are, or may be, exceeded.

Designation of controlled areas C2 for the contamination risk	
Radionuclide	**Minimum activity ($Bq.cm^{-2}$)**
Ac-227, U-232 and isotopes of Am, Cm, Cf, Pu, Th	0.2
Pb-210, Ra-228 and alpha emitters not otherwise specified	0.4
Radionuclides not otherwise specified	4
C-14, S-35, Cr-51, Mn-54, Fe-55 or Ni-63	40

An area is designated as a contamination controlled area C3 when the air activity, averaged over a working period not exceeding 8 hours, exceeds or may exceed the values given below:

i) for known radionuclides, the minimum airborne concentrations in the table below (column 2),

ii) if several known radionuclides are present, a ratio Q of 1, where $Q = \sum Q_p/Q_{lim}$, Q_p is the quantity of a radionuclide and Q_{lim} is the value for that radionuclide given in the table below,

iii) for a mixture of unknown radionuclides, 0.01 Bq/m^3 (alpha) or 10 Bq/m^3 (beta).

If the airborne activity exceeds the minimum activity but is less than four times this minimum value (maximum value given in column 3), an Accredited Health Physicist may decide, based on ALARP criteria, not to designate the area as C3.

The risk assessment for work in such an area must include an estimate of the predicted effective dose by inhalation to persons. If this dose exceeds 100 μSv, a C3 area must be designated for all or part of the work.

Controlled area C3 designation criteria for the contamination risk		
Radionuclide	**Minimum activity ($Bq.m^{-3}$)**	**Maximum activity ($Bq.m^{-3}$)**
Cs-134	43	172
Cs-137	62	248
Ca-45	180	720
C-14 (CO_2)	64,100	256,400
C-14 (any form)	245	980
Cl-36	82	328
Cr-51	11,600	46,000
Co-58	245	980
Co-60	24	96
H-3 (tritiated water steam)	16,000	64,000
I-131	38	152
Fe-55	450	1,800
Fe-59	130	520
Mn-54	350	1,400
Ru-103	190	760
Ru-106	12	48
Ag-110m	57	228
Sr-90	5.4	22
S-35 particles	380	1,520
S-35 steam	600	2,400
Radon	50	200
General (alpha)	0.01	0.04
General (beta)	10	40

CRSI 2 – Appendix C Designation and demarcation of contamination controlled areas

C2.1 A Contamination Controlled Area C2 shall be designated where the loose contamination level averaged over an area not exceeding 1000 cm2 in the case of a floor, wall or ceiling, or 300cm2 in any other case, exceeds or may exceed the following values:

- either:

For Ac-227, U-232, and isotopes of Am, Cm, Cf, Pu, Th	*0.2 Bq/cm^2 (notes 1,2)*
For Pb-210, Ra-228 and alpha emitters not otherwise specified	*0.4 Bq/cm^2 (note 2)*
For Radionuclides not otherwise specified	*4 Bq/cm^2*
For C-14, S-35, Cr-51, Mn-54, Fe-55 or Ni-63	*40 Bq/cm^2*

- note 1: this derived value assumes that high toxicity alpha nuclides, e.g. Ac-227, and isotopes of Cm and Cf are not present in isolation. If these nuclides are found in isolation then the surface contamination limit should be determined using isotopic considerations or reduced to 0.01Bq/cm^2.

- note 2: these values assume that the contamination is fairly localised in relation to the work area. Where widespread contamination is present an airborne hazard could be generated and these values should be reduced by a factor of 10.

CRSI 2 – Appendix C Designation and demarcation of contamination controlled areas

C3.1 A Contamination Controlled Area C3 shall be designated where the air activity, when averaged over a working period not exceeding 8 hours, exceeds or may exceed the values given below:

i) For known radionuclides, the air concentration listed for that nuclide in column 2 of Table C1.

ii) Where more than one known radionuclide is involved, a Quantity Ratio of one, where the Quantity Ratio is defined as:

Quantity Ratio = Σ Qp / Qlim

where Qp is the quantity of a radionuclide and Qlim is the value for that radionuclide given inTable C1.

iii) For a mixture of unknown radionuclides, a value of 0.01 Bq m^{-3} (alpha) and 10 Bq m^{-3} (beta) is to be used.

C3.2 Where the air activity exceeds the levels given in 3.1 above but is less than four times these values (column 3 of Table C1), an Accredited Health Physicist may decide, based on ALARP considerations that the designation of a C3 Area is not required. The risk assessment for work in such an Area must include an estimate of the likely effective dose from inhalation to individuals and where this may exceed 100 uSv a C3 Area shall be designated for all or part of the work. This provision shall not be used retrospectively to explain a failure to designate a C3 Area.

C3.4 The levels of airborne activity at which a Contamination Controlled Area C3 must be designated may be averaged over a period not exceeding 8 hours. In some instances it may be more appropriate or necessary to run air samples for periods shorter than 8 hours and extrapolate the results to an 8-hour exposure. In these cases, the sampling should be such that it does not underestimate the 8-hour exposure level. Similarly, samples taken over periods longer than 8 hours should encompass typical working periods and must not underestimate exposure in any 8 hour working period. It is important that when a sample is taken, the sampling period encompasses any periods of work activity in the Area and that any airborne activity arising from the work is properly assessed.

3.2.3. Specific aspects of controlled areas for radiography sites

The extent of the controlled area R4 for open site radiography (i.e. without a shielded enclosure) must take into consideration:

- the existing designation of the work area in which the radiography will take place
- the planned exposure time and the anticipated dose rates at the site boundary (dose rates averaged over 8 working hours)
- the practicability of demarcation and the need to keep doses ALARP.

If the radiography takes place in a controlled area, the dose rate at the boundary of the radiography site must normally be limited to the maximum limit of the controlled area involved, unless special authorisation is granted by an accredited health physicist.

If the radiography takes place outside a controlled area, the dose rate at the boundary of the demarcated radiography site must not exceed 7.5 µSv/h.

CRSI 11 - Appendix E - Establishing a controlled area for open site radiography

E1.1 In determining the extent of the Radiation Controlled Area R4 (see 4.2.10) for Open Site radiography the following shall be considered:

(a) The maximum permitted radiation dose rate at the Radiography Site boundary including:

(i) the existing designation of the work area in which the radiography will take place;

(ii) the planned exposure time(s) and the anticipated time averaged dose rates at the Radiography Site boundary (dose rate at that place averaged over any 8 hour period);

(iii) the practicalities of demarcation, security, emergency exits, watchmen (see 4.2.13) and the requirement to keep doses ALARP.

For radiography taking place within an existing Radiation Controlled Area the dose rate at the barrier should normally be limited to the maximum allowed for that category of Area, although a higher barrier dose rate may be specified by an Accredited Health Physicist following consideration of the above.

For radiography taking place outside a Radiation Controlled Area, the extent of the barriers should be determined using the same considerations as above subject to a maximum dose rate at the barrier of 7.5 µSv/h. Table E1 gives the distances (in air) from an unshielded Source at which dose rates of 7.5 µSv/h (the maximum acceptable outside of controlled areas) and 50 µSv/h (the maximum for a Radiation Controlled Area R2) will be measured.

In particular circumstances, such as when radiography is to take place within an existing Radiation Controlled Area R4 (e.g. a locked off room) it may be ALARP to forgo the setting up of complete barriers and warning signals and to exclude persons from the working area and control access by alternative means. In such cases the advice of an Accredited Health Physicist shall be sought. The Radiation Controlled Area shall extend over as small an area as practicable and not extend to a size which cannot be effectively supervised. Ideally, the Lead Radiographer shall be able to view the whole of the Radiography Site from the operating position.

(...)

3.2.4. Specific aspects of controlled areas relating to on-site transport and movements of radioactive substances

The instruction on on-site transport and movements of radioactive substances (CRSI 9) stipulates that, in general, designation of controlled areas for transport of radioactive substances is the same as that defined in CRSI 2.

Designation of controlled and supervised areas at locations under the control of the company (CRSI9 Appendix C)

The designation of controlled areas at Company locations is covered in CRSI2. The designation of a controlled area should not normally be required during normal transport operations. In cases however where packages with a high surface dose rate or transport index are being carried the following areas may require to be classed as temporary controlled areas and described as such in local rules:

(a) the area around and within a vehicle (including the drivers cab) which has been loaded and is held for a significant period prior to despatch;

(b) areas around and on vehicles during unloading or transfer operations.

Designation of controlled or supervised areas in and around vehicles during transport

There should be no designation of controlled areas during normal transport operations except in the following cases:

- Driver's cab:
  The driver's cab shall be designated as a controlled area if the dose rate exceeds 3 µSv/h.
  If the dose rate is between 0.5 and 3 µSv/h, the cab must be designated as a supervised area.

- Vehicle body outside the drivers cab during transport:
  During shipment of packages such as fuel (with maximum surface dose rates of 10 mSv/h), access to the vehicle must be restricted to classified persons. The area must be designated as a controlled area.

CRSI 9 Appendix C
Designation of controlled areas in and around vehicles during transport
3.1 During normal transport operations the conditions requiring a controlled area to be designated will not normally exist except in the following circumstances:
(a) The drivers cab
- The drivers cab shall be designated as a controlled area if the dose rate at any normally accessible part is in excess of 3µSv.h-1. Where the dose rate is less than 3 µSv.h-1 but exceeds 0.5 µSv.h-1, then the cab shall be designated as a supervised area.
- The radiation dose rate at any normally occupied position in the cab should not exceed 20 µSv.h-1.
- If the vehicle cab is designated as a controlled area the driver and anyone else travelling in the vehicle shall be issued with a dosemeter and written arrangements prepared by an Accredited Health Physicist.(See CRSI 7 and 10) No one shall be allowed to travel on or in a vehicle transporting R/A substances except in accordance with the transport regulations.

(b) Vehicle body outside the drivers cab during transport
- Where a shipment is being made under 'Full Load' or 'Exclusive Use' (to allow the shipment of packages with surface dose rates up to a maximum of 10 mSv.h-1), then access to the vehicle should be restricted to classified persons. The area within the enclosure must be designated as a radiation controlled area during loading, unloading and shipment.

3.2.5. Demarcation of controlled areas

The boundary between a controlled area and other areas must be physically demarcated (wall) or, if this is not possible, by other means. R2, R3 and R4 areas must be clearly delineated.

Permanent controlled areas R4 must, where practicable, be separated from other areas by doors kept locked to prevent unauthorised entry.

In some cases, an area can be designated temporarily as R4. This new R4 area must, where reasonably practicable, be segregated by locked doors. If this is not possible, barriers must be used to segregate the area.

Access to areas with dose rates greater than 1 Sv/h at 0.5 m must be controlled by a double-key system.

Access to contaminated areas must be through a change room (or sub-change room) with surmountable area barriers, providing suitable protective clothing.

CRSI 2

B2.3 The boundary between a Radiation Controlled Area and other areas should be physically demarcated e.g. by walls, or where this is not reasonably practicable, delineated by some other suitable means. The boundaries between R2, R3 and R4 Radiation Controlled Areas should be clearly delineated.

B3.1. Permanent Radiation Controlled Areas R4 shall, where practicable, be segregated from other areas by doors that must normally be kept locked to prevent unauthorised entry.

B3.2 Radiation Controlled Areas R4 designated because of Very High Transient Dose Rates shall be treated as permanent Radiation Controlled Areas R4. Such Areas shall not be declassified or reclassified as a lower category area unless Effective Devices have been introduced to prevent the recurrence of the Very High Transient Dose Rates.

B3.3 Where access is required to Radiation Controlled Areas R4 where Very High Transient Dose Rates can occur, Effective Devices to prevent the Very High Transient Dose Rates occurring during the access period shall be used whenever practicable.

B3.4 Any Radiation Controlled Area R4 which contains plant or apparatus whose operation may result in a High Transient Dose Rate, shall, where reasonably practicable, be provided with a suitable radiation monitoring system to alert persons in the vicinity when a significant change in radiological conditions takes place.

B3.5 Where an Effective Device in 3.2 or 3.3 depends on a key exchange principle, all keys shall be kept under the control of the Location Manager or his nominee and written procedures for the issue and use of such keys detailed in local management instructions. Any spare key shall only be issued in accordance with written arrangements approved by the Location Manager or his nominee.

B3.6. Temporary Radiation Controlled Areas R4 shall, where reasonably practicable, be segregated by locked doors. Where the provision of locked doors is not reasonably practicable, barriers must be used to segregate the Area. These barriers must be such that they cannot be crossed inadvertently and must carry a sufficient number of notices so that the designation of the Area is clear from all possible directions of approach. Except where a temporary Radiation Controlled Area R4 has been set up for testing, measurement or examination at an Open Site, every effort must be made to avoid the need to designate a temporary R4 Area which cannot be segregated by locked doors. Thus, if the designation is due to the temporary storage of radioactive substances in an Area, the material must be moved to a properly shielded store (or returned to its normal in-service location) as soon as possible. If temporary designation is required because of the build-up of radioactive substances in a tank or pipe, consideration must be given to the provision of shielding or the removal of the accumulated radioactive substances.

B3.10 Where an Area exists with dose rates in excess of 1 Sv/h @ 0.5 metre and effective devices are not fitted to prevent entry with the high dose rate present the area shall be posted with a Very High Radiation Area sign as defined in BEG/SPEC/SHE/RPS/007. Access to the area shall be controlled by a double key system. One key shall only be issued to, and retained by, a Competent Person (Nuclear Radiation). The issue and return of such keys shall be carried out in accordance with local management instructions.

C5.2 A Change Facility shall be provided at the access to each Contamination Controlled Area and entry to, or egress from, such Areas must be through a Change Facility.

CRSI 2

C6.1 Permanent Sub-Change Rooms that provide routine access to Contamination Controlled Areas shall as a minimum, have the following:
(a) A surmountable barrier between the part of the room which is free of contamination and the part which may be contaminated; the top of the barrier must be uncontaminated and must be maintained in a clean condition;
(b) space for changing into protective clothing and storage for personal clothing;
(c) hand and clothing monitoring equipment;
(d) facilities for decontamination.
and where reasonably practicable the following:
(e) equipment suitable for monitoring items to be removed from the Contamination Controlled Area;
(f) bins for items of protective clothing which are found to be defective prior to use;
(g) facilities for showering;
(h) a telephone on the clean side of the barrier to allow notification of the appropriate persons should anyone be found to be contaminated after leaving the Contamination Controlled Area.
C6.2 A temporary Sub-Change Room that provides infrequent access to a permanent or temporarily established Contamination Controlled Area shall as a minimum, have the following:
(a) A surmountable barrier between the part of the room which is free of contamination and the part which may be contaminated; the top of the barrier must be uncontaminated and must be maintained in a clean condition;
(b) space for changing into protective clothing and storage for personal clothing;
(c) hand and clothing monitoring equipment; or in close proximity where it is not reasonably practicable for this to be located within the temporary Sub-Change Room. and where reasonably practicable the following:
(d) items d, e, f, & h in 6.1.

3.3. Access conditions

CRSI 11 describes the access and working conditions in supervised and controlled areas. In general, only classified workers can work in these areas. They must have received radiation protection training approved by British Energy (BE). Persons entering a contamination controlled area must have received protective clothing training. Protective clothing is defined by an accredited health physicist.

3.4. Area marking

Areas must be marked by signs at their entrances (see posting signs below).

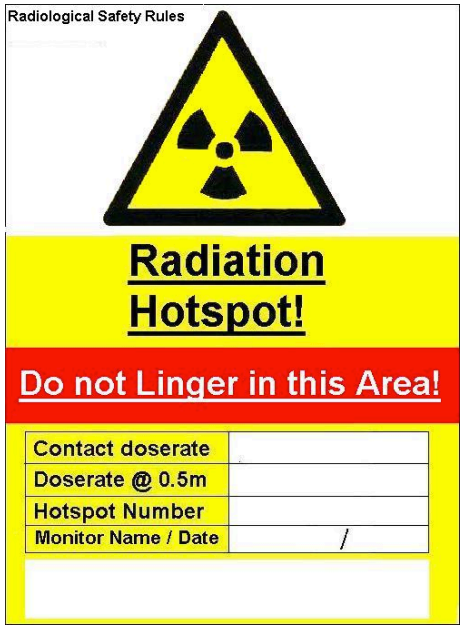
Areas with dose rates greater than 1 Sv/h at 0.5 m that are not locked mechanically must have a specific “Very High Radiation Area” sign.

The signs for contaminated areas must also give the protective clothing required for area access.

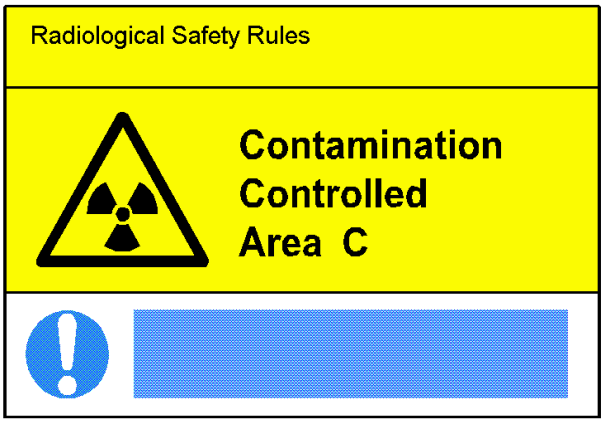
Supervised area sign

Controlled area sign

Hot spot sign (high dose rate)



Contaminated area sign (C2 or C3)



4. RULES IN THE MEDICAL SECTOR

The procedures for the designation of radiation areas in the medical sector are based on the requirements of IRR99 and the associated ACOP. The details given here are those recommended by the joint working group of the Institute of Physics and Engineering in Medicine, the National Radiological Protection Board and the Health and Safety Executive in 2002 [8].

4.1. Area delineation

The medical and dental guide is based on three types of area:

- non-designated areas
- supervised areas
- controlled areas.

In general, the following should be designated as controlled areas:

- areas concerned by radiopharmacy activities,
- areas containing sealed sources for radiotherapy,
- departments or rooms used for patients undergoing radiotherapy or brachytherapy,
- areas containing fixed X-ray generating equipment,
- areas where there is a significant risk of radiological contamination outside the working area.

If the radiation sources have been eliminated (e.g. X-ray generator shut down, sources removed), the designation of the controlled area may be temporarily withdrawn. The guide notes that it may be more convenient for the controlled area designation to be permanent and to allow access according to arrangements in writing.

The designation of an area must be confirmed periodically by monitoring and reviewing the working conditions, preferably annually or at least every three years, or following a significant change in situation.

For more precise delineation of controlled areas, the guide recommends the following dose rate criteria:

Guideline dose rated used to designate areas

Criterion	Controlled areas	Supervised areas	Unsupervised public areas
IDR	> 2000 μSv/h	> 7.5 μSv/h	< 7.5 μSv/h
TADR	> 7.5 μSv/h	> 2.5 μSv/h	< 2.5 μSv/h
TADR 2000	> 3 μSv/h	> 0.5 μSv/h	< 0.15 μSv/h *

* 0.15 μSv/h is three-tenths of 0.5 μSv/h or 300 μSv/year – which is an appropriate dose constraint for an office worker assuming an occupancy of 2000 h per year.

IDR: instantaneous dose rate: instantaneous dose rate averaged over 1 minute

TADR: Time-averaged dose rate: estimated dose rate averaged over 8 hours taking account of the use and the workload for a worst-case day (occupancy factor equal to 1)

TADR 2000: Time-averaged dose rate 2000: estimated dose rate averaged over 2000 hours taking into account occupancy in addition to use and workload.

Flow charts for determining the designation of areas according to whether they are public areas are given in figures A11.1 and A11.2 below.

The instantaneous dose rate (IDR) is used as the starting point for designation, as it is easily measurable and not dependent on workload. Then the TADR is used (workload and use), and finally TADR 2000 (occupancy over the year).

The IDR should ideally be measured by integrating the dose over the duration of the exposure and time-averaging over 1 minute, to avoid potential errors due to:

a) the pulsed nature of many radiation sources
b) their possibly short duration
c) the slow response times of many dosemeters at low dose rates.

Calculated IDRs should be confirmed by measurements.

For existing installations, it will normally be sufficient to use the TADR dose constraint as the basis for area designation (except for areas with high public occupancy, for which use of the TADR2000 is advised).

In contrast, new installations must satisfy the TADR and TADR2000 dose constraint values. Wherever practicable, a dose constraint of 0.3 mSv per year must be applied at the design stage so that no designation is needed for adjacent areas.

If, in spite of a low ambient dose rate, there is a probability of contamination or of accidental exposure, an area must be designated as a controlled area or supervised area on the basis of the potential exposure.

Figure A11.1 Designation of controlled and supervised areas (numbers in µSv/h)
Non-public areas

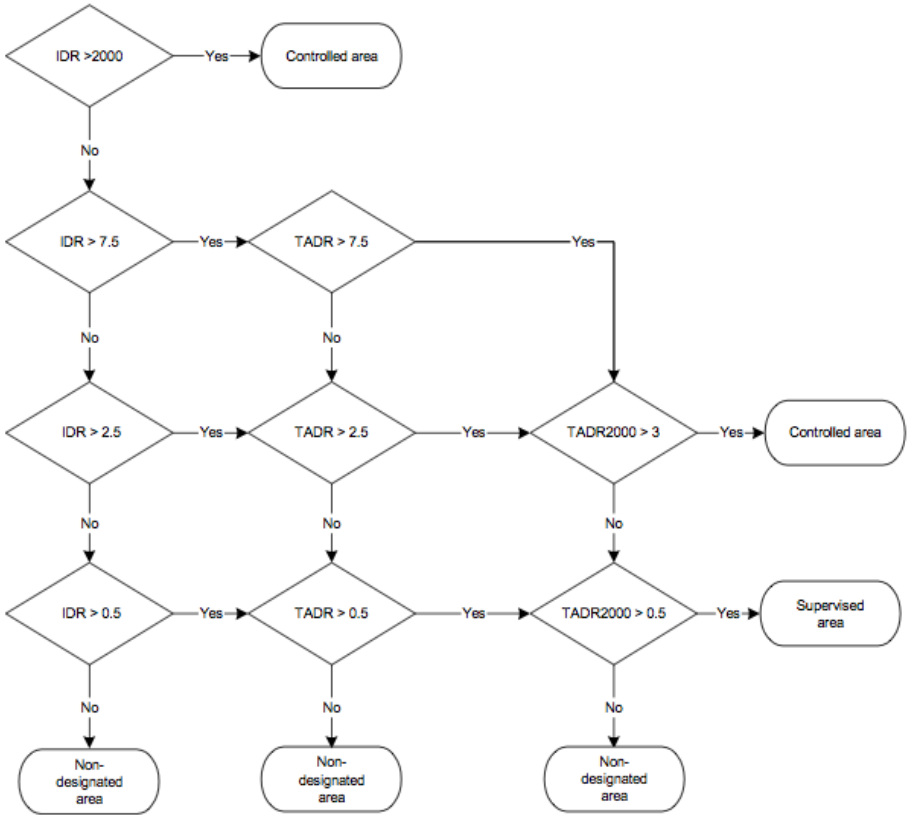
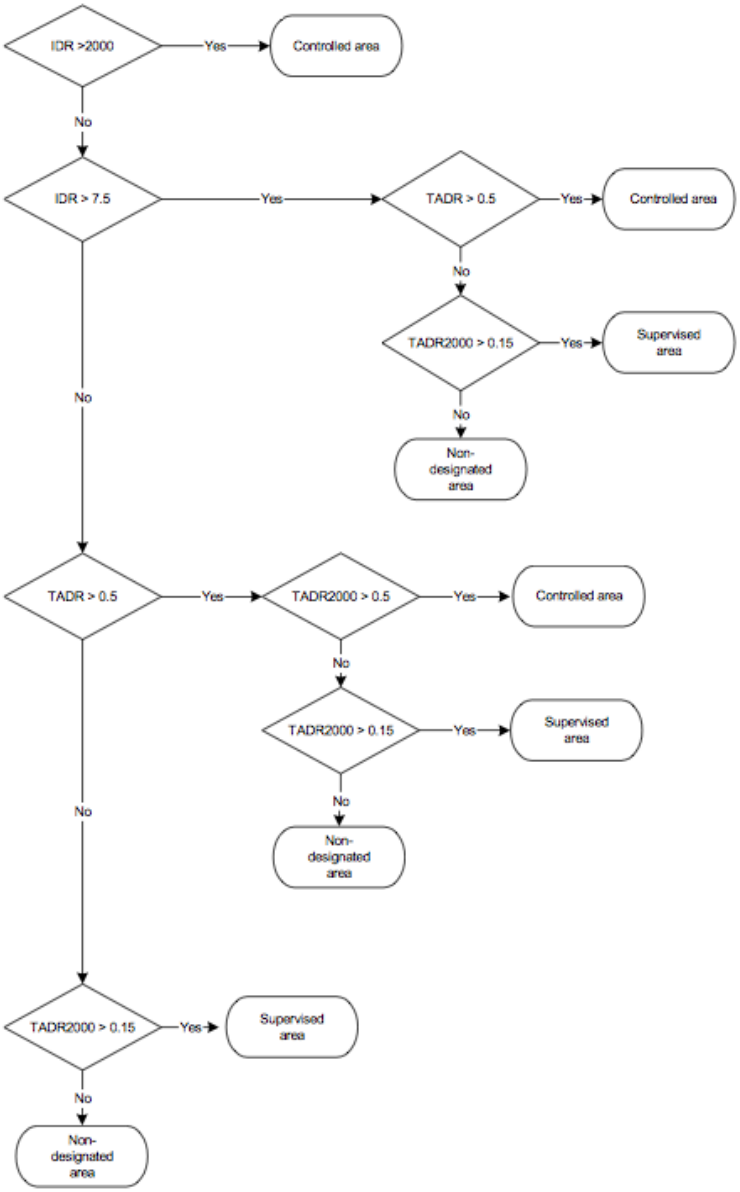


Figure A11.2 Designation of controlled and supervised areas (numbers in μSv/h)
Public areas

Note that the systems of work to restrict exposures and enable members of the public to enter a controlled area should ensure that doses are restricted ALARP with a dose constraint of 0.3 mSv per year, otherwise there should be no public access to these areas. Comforters and carers should also have their doses restricted but see paragraphs 1.72 to 1.74.



4.2. Marking

The entry to a controlled area must have a warning notice stating that the area is controlled and incorporating the radioactivity symbol. It should also give the reasons why the area is controlled (e.g. X-rays, unsealed sources) and the access conditions.

An illuminated warning light may also be installed to indicate when access is strictly forbidden (for example during radiotherapy treatment).

Figure A12.3 Sign at the entry to a controlled area

Figure A12.4 Sign on a storage cabinet for radioactive materials

Figure A12.5 Sign on the door of an X-ray room

Figure A12.6 Safety signs and notices (in two languages) at the entrance to a radiotherapy bunker; the illuminated interlocked warning signals are shown in use in the lower image

4.3. Extracts from the guide

1. General principles

1.52 Radiopharmacies, radiation areas containing sealed sources used for radiotherapy, and wards, side-wards or rooms used for patients undergoing radionuclide therapy or brachytherapy should all be designated as controlled areas. Radiation areas containing fixed X-ray generating equipment should usually be designated as controlled areas. Areas where there is a significant risk of radionuclide contamination outside the working area will also need to be designated as controlled. Other radiation areas, in which the likely exposures are much lower than in the controlled areas, may need to be designated as supervised areas.

1.53 There should be a documented risk assessment for each controlled area, clearly identifying the control measures and actions required to restrict exposure. These may be summarised in the local rules.

1.54 Radiation areas are designated as controlled to ensure that exposures from radiation sources are properly restricted. Consequently, the structural shielding around a designated area should limit the extent of exposures outside that area. It follows that only in special circumstances, where it is not otherwise practicable, should adjacent areas, not themselves containing a radiation source, also need to be designated as controlled. Outside a controlled area, the exposures should not exceed those permitted for a supervised area and, where the employer cannot exercise supervision, the radiation levels should be even lower so that radiation area designation is not required. In this case, access is freely available to members of the public and consequently the non-designated area can be deemed to be a public area, for example, outside the external boundaries to a room or department, hospital corridors, public and patient waiting areas, the visitors' coffee bar.

1.55 Structural radiation shielding will be adequate when adjacent areas are protected, preferably so that no area designation is needed or, where that is not practicable, as supervised radiation areas. The determination of what is adequate structural shielding should be clearly documented by the employer in conjunction with the RPA and include consideration of present and future workload, beam quality, use, occupancy and appropriate time-averaging. Dose limitation and the ALARP principle both apply.

1.56 The adequacy or otherwise of the shielding should be verified by area monitoring. Results of monitoring including the measured IDR* and calculated TADR† at commissioning should be documented. When a particular group of people is likely to be exposed, the TADR2000‡ may also be calculated or determined from the results of appropriate environmental monitoring, with due consideration for occupancy of the group or particular individuals. The appropriate dose-rates to aid in the designation process are given in Table 1.2. Appendix 11 presents flow diagrams and further detailed guidance on designation.

1.58 The entrance to a controlled area should be marked with a warning notice that should state that the area is controlled. It should incorporate a radiation warning sign. It should also include other precise information, such as the reason why the area is controlled, e.g. "x-radiation" or "unsealed sources", and whether or not entry is permitted together with any conditions. Signs should give sufficient information to alert employees to the possible risks arising from the source (e.g. external γ, cloud β, inhalation or ingestion) and to enable employees to take appropriate action before entering the area (e.g. to wear appropriate personal protective equipment). An illuminated warning light (preferably at eye level) may accompany the warning notice to indicate when access is strictly forbidden, for example during radiotherapy when the beam is "on" and during diagnostic X-ray exposures if entry is directly into an unprotected area of the room. The light should be at the room entrance at a visible height and would normally incorporate appropriate wording depending on the conditions. (Appendix 12 gives examples.)

1.59 Systems of work (including written arrangements in local rules for non-classified staff) must be provided (IRR99 regulation 8(2) [1] and L121 paragraph 104 [2]) to restrict exposures for any persons working in the controlled area. If an X-ray generator has been effectively isolated from the electrical supply, or if all radioactive sources have been removed (e.g. to a store) and residual contamination is negligible (see later chapters for guidance), the designation can be temporarily withdrawn provided the warning notices reflect the correct designation. It may be more convenient for designation to be permanent and to allow entry under a written arrangement.

1.60 The designation of each radiation area should be confirmed periodically by undertaking monitoring, and reviewing the working conditions. This should be performed initially at commissioning and preferably annually or at least 3-yearly thereafter, or when the situation or practices change significantly (L121 paragraph 52 [2]. It is insufficient to rely on the records of assessed doses of individuals.

1.61 Measurements must be made within each controlled area using personal monitoring or other suitable measurements such as area monitoring. These should demonstrate that any written arrangements in local rules are effective in ensuring that doses received by workers in the controlled area are ALARP and do not exceed 6 millisievert (mSv) per year or 3/10 of any dose limit for non-classified staff. Records of any such monitoring must be kept for at least 2 years to confirm appropriate designation and satisfactory working arrangements.

Appendix 11

1. The instantaneous dose-rate (IDR) is used as the starting point for designation, as it is easily measurable and not dependent on workload. In the flow diagrams, a staged structured assessment of IDR has been used first, then workload and use (to estimate the time-averaged dose-rate (TADR) and finally occupancy to estimate the time-averaged dose-rate over the working year (TADR2000), to determine the need for designation. This sequence forms the basis for the risk assessments for these areas.

2. The IDR should be measured, ideally by integrating the dose over the duration of the exposure (highest exposure used clinically but within the ratings of the unit) and time-averaging over 1 minute, to avoid potentially erroneous results due to
   (a) the pulsed nature of many radiation sources
   (b) their possible short duration, and
   (c) the slow response time of many dosemeters at low dose-rates.

   Calculated IDRs should be confirmed by measurement.

3. For existing installations it will normally be sufficient to work to the TADR in designating areas, except for areas of high public occupancy (busy thoroughfares, offices, etc) when it is recommended to use also the TADR2000.

4. Areas where the TADR exceeds 7.5 µSv/h should normally be designated as controlled, with appropriate controls to ensure ALARP below the individual dose limit.

5. Areas where the TADR exceeds 2.5 µSv/hr (but less than 7.5µSv/h) can normally be designated as supervised, provided the TADR2000 is less than 3 µSv/h (otherwise it will need to be designated as controlled). This will be satisfied in all cases where the occupancy factor is less than 0.4 for a TADR up to 7.5 µSv/h (800 hours or 100 days a year).

6. By default, non-public areas* where the TADR is not more than 2.5 µSv/h are non-designated. However, appropriate consideration of occupancy should be made to ensure that persons present in these areas would not exceed 1mSv/y (see IRR99 regulation 16(3)(b) [1]). This requires the TADR2000 to be less than 0.5 µSv/h, a condition which will be satisfied if the occupancy factor is less than 0.2 (400 hours or 50 days a year) for a TADR up to 2.5 µSv/h. If this is not satisfied, the area may need to be supervised.

7. Non-designated areas, which do not need to be supervised and to which the general public have free access (unsupervised public areas), should normally have a TADR less than 0.5 µSv/h. However, the area can be non-designated for a TADR up to 2.5 µSv/h provided that the TADR2000 is less than 0.15µSv/h (occupancy factor is less than 0.06 or 120 hours (15 days) per year).

8. Any area into which members of the public or employees untrained in radiological protection are likely to enter, and where the IDR exceeds 7.5 µSv/h, should normally be considered for designation as a controlled area (L121 paragraph 249 [2]). The controls should ensure that no member of the public is likely to exceed a dose of 0.3 mSv per year. However, if the IDR is intermittent and a risk assessment identifies that the TADR value complies with another designation indicated in Table 1.2, designation as a controlled area may not be necessary.

9. New installations should normally be designed to satisfy both the TADR and TADR2000 values given in Table 1.2 (or pre-determined values similarly based on an appropriate dose constraint). Wherever practicable, a dose constraint of 0.3 mSv per year should be applied (0.15 µSv/h TADR2000) at the design stage so that no designation is needed for adjacent areas.

10. If the TADR2000 is more than 3 µSv/h the area will need to be designated as controlled.

11. This appendix and the flow charts indicate a prudent approach to designation on the basis of ambient dose equivalent rates. If in spite of normally low ambient dose-rates, there is a potential for contamination, or for accidental exposure, the area should be designated as controlled or supervised, as appropriate, on the basis of the potential exposures.

5. REFERENCES

[1] **The Ionising Radiations Regulations 1999** (IRR99), Statutory Instrument 1999 No. 3232

[2] Health and Safety Executive, **Work with Ionising Radiation - Ionising Radiations Regulations 1999 Approved Code of Practice and guidance**, 2000

[3] Health and Safety Executive, **Safety Assessment Principles for Nuclear Facilities,** 2006 Edition - Revision 1

[4] Health and Safety Executive, **Technical Assessment Guide no. 38 – Radiological Protection** – 2009 (rev 2011).

[5] British Energy radiation protection instructions
Company Radiological Safety Instruction 2 (CRSI 2): **Designation of Controlled and Supervised Areas**
Company Radiological Safety Instruction 9 (CRSI 9): **Transport and Movement of Radioactive Substances**
Company Radiological Safety Instruction 10 (CRSI 10): **Entry to and Work in Supervised and Controlled Areas**
Company Radiological Safety Instruction 11 (CRSI 11): **Radiography and the use of Ionising Radiation for Calibration, Testing and Inspection**

[6] **Medical and Dental guidance notes: A good practice guide on all aspects of ionising radiation protection in the clinical environment**, Institute of Physics and Engineering in Medicine, NRPB, HSE 2002.

APPENDIX 1. EXPLAINING THE BRITISH ENERGY CRITERIA

The rules adopted by British Energy for the classification of areas are explained in a document drafted by an industry radiological protection coordination group (BNFL, British Energy, Nuclear Electric) in 2002.[9] The document gives the rationale applied to define the boundaries between the supervised areas and the various controlled areas.

This appendix reproduces extracts from this document.

Designation of Supervised Areas

The decision to designate a supervised area depends upon the assessment of likely doses in that area, expected occupancy and the probability that radiological conditions may change. Across the sector designation of supervised areas is based exclusively on external radiation, no organisation elects to designate supervised areas on the basis of internal radiation as it is considered that contamination always requires to be controlled. The sector shares the view that this option prevents possible confusion for a perceived requirement to designate a controlled area where there are two overlapping supervised areas (external and internal).

Often supervised areas are designated around well-situated permanent buildings on larger sites where the dose rates are of a fraction, up to a few microsieverts per hour and where basic controls to access are easily enforced. Designation is required where a person is likely to receive a dose in excess of 1 millisivert a year in such areas. Warning signs may be posted although descriptions of their locations are included within records and local rules.

Persons spending extended periods in supervised areas possibly could, from dose assessment considerations, receive a 'significant dose'. The use of supervised areas for offices or other areas which require frequent access by persons who do not work with radiation or are not designated as 'classified persons' should therefore, where practicable be avoided. Where the use of such areas is unavoidable routine dose assessments shall be carried out (by the employer, not by individual dosemeter issue) to demonstrate that the doses received by persons in these areas are not 'significant' and are as low as reasonably practicable.

Note that the boundaries of radiation supervised areas ordinarily do not relate directly to the annual dose limits given in the IRRs 1999. The overriding requirement however, is to keep doses to persons within the relevant annual dose limits. For example, annual doses to persons outside designated areas shall not exceed the dose limits for 'other persons'. In addition, doses to persons who cannot be regarded as being directly involved in work with ionising radiations and to employees aged under 18 shall be kept below the dose limits for 'other persons'. These persons cannot therefore work full time in a radiation supervised area.

If a person can receive an 'effective dose' of more than 1 mSv in a year, or an 'equivalent dose' greater than $1/10^{th}$ of any relevant dose limit in respect of an employee aged 18 years or over, an area shall be designated as a supervised area.

Radiation supervised areas shall normally be designated when the dose rate exceeds, or may exceed, the lower boundary value. In some cases the use of a time averaged dose rates over a period longer than one minute may be used with the agreement of a Radiation Protection Adviser. Notices of the type provided in (*Figure A*) may be used to demarcate such areas.

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[9] Inter-Industry Radiological Protection Co-ordination Group, Best practice Paper no. 1, 'Designation of Radiological Areas', BE Paper HPM-6/2001.

Rationale:
Radiation Supervised Area, R1, radiation supervised area lower boundary = 0.5 μSv/h and upper boundary = 3 μSv/h.

- The lower boundary corresponds to 1 mSv per year for 2000 hours' working, the 'effective dose' limit for 'other persons'.
- The upper boundary corresponds to the 6mSv per year limit for the designation of 'classified persons' for 2000 hours working.

Designation of Radiation Controlled Areas (external radiation)

Designating radiation controlled areas according to the ambient dose rate is the most pragmatic and common approach. Within the sector, the radiation fields around and within plant areas are usually constant, with only occasional transient doses (usually anticipated by plant processes). The emphasis on designation is almost entirely based on instantaneous dose rate. Those in the sector will have developed their own protocol for delineating several different categories for radiations areas. This may be by increasing numbers R1, R2, R3 etc (the higher the number the greater the risk and corresponding imposed controls) or by colour ('traffic light system'). In practice, instantaneous dose rate reference levels often serve as upper or lower bounds on when designated areas are required. Time averaged dose rates are seldom used to delineate areas, but in both methods conservatism is usually adopted by assuming a continuous occupancy e.g. 2000 hours per year at the boundary between supervised and radiation controlled areas. The provision of appropriate warning signs at the entrance to each radiation controlled area is widely adopted.

Designating whole buildings, rooms, and plant systems as radiation controlled areas normally makes it easier to restrict access. Although dose rate is likely to be a significant factor in deciding whether an area is designated as controlled, it is not necessarily used to decide where the boundaries of the area occur. Instead, the greater emphasis may be on the positioning of natural boundaries or, where they do not exist, restricting access to persons. As a consequence ambient dose rates within each area is usually much lower than those prescribed for delineation, although 'hot spots' may be specifically identified so that employees do not lose sight of significant hazards. Very hazardous areas are generally made impossible to enter either due to physical barriers and safety systems, or due to continuous control and supervision at the point of entry.

Rationale:

Radiation Controlled Area, R2, radiation controlled area lower boundary = 3 μSv/h and upper boundary = 50 μSv/h.

- The lower boundary corresponds to the upper boundary of supervised area.
- The upper boundary has no technical reason for the upper dose rate limit, but this value ensures (with other control measures) that R2 areas are relatively low risk e.g. 1 mSv in 20 hours working.
- If any person working in an area is likely to receive an 'effective dose' greater than 6 mSv in a year or 'equivalent dose' greater than $3/10^{th}$ of any relevant dose limit in respect to employees aged 18 years or over, the area must be designated as controlled.
- Where the hands of a person can enter an area and the dose rate in that area exceeds 75 μSv/h, the area must be designated as a controlled area.

Radiation Controlled Area, R3, radiation controlled area lower boundary = 50 μSv/h and upper boundary = 500 μSv/h.

- The lower boundary corresponds to the upper boundary of R2.

- The upper boundary corresponds to one tenth of the dose limit in any working period of 4 hours (i.e. 2 mSv in 4 hours or 500 μSv/h).
- There is a possibility that an individual may leave an R3 area and discover that his issued electronic personal dosemeter (EPD) has been defective; where 4 hours is the longest period, which could elapse before a defective EPD was noticed.
- R3 areas must be clearly identified from all directions of approach; doors and physical barriers may be used to prevent unintended entry.

Radiation Controlled Area, R4, radiation controlled area lower boundary = 500 μSv/h and upper boundary = unlimited.

- The lower boundary corresponds to the upper boundary of R3.
- No upper boundary is defined as arrangements for entry to R4 areas are tightly controlled to limit doses received with the level of control depending on measured or potential dose rates. Within all R4 areas, lower dose rate short term 'havens' should be identified to assist in maintaining low doses.
- Permanent R4 areas shall were practicable be locked shut, other than when work is in progress. Temporary R4 areas shall where reasonably practicable be locked shut, other than when work is in progress. When work is in progress physical barriers shall be used to prevent inadvertent access.
- Keys for R4 areas must be issued and returned in accordance with safety instructions. Locks fitted to R4 doors must close automatically on opening but can be opened from inside the area allowing unrestricted exit.
- In R4 areas designated because of very high transient dose rates, effective devices must be installed, maintained and utilised to prevent such dose rates occurring during access periods. It is usual, in such area, to provide radiation monitoring warning systems to alert persons in the vicinity when there is any significant change in radiological conditions (reliance is not placed solely on an EPD).

Designation of Contamination Controlled Areas (internal radiation)

A qualitative approach is adopted to designation, as there are uncertainties associated with likely internal doses and the principal need to employ contamination control. The designation of contamination controlled areas are based on the requirement to keep the exposure of persons as low as reasonably practicable and ensure that persons do not receive a significant exposure from ingestion or inhalation. To minimise the spread of contamination, the extent of any area should be minimised whenever practicable taking into account the requirements for area control. Where reasonably practicable contamination controlled areas should be decontaminated to allow their declassification. Places that cannot physically be entered do not normally need to be designated, however, designation consideration must still be given to preventing the spread of contamination.

As with external radiation, the nuclear industry may apply different categories of contamination controlled areas C2 and C3 etc, rated according to increasing radiological hazard. The likelihood of surface contamination is nearly always a major factor in determining whether an area should be designated as controlled. The values used are usually based upon the most radiotoxic alpha and beta emitters likely to be encountered (cautious approach). Higher permissible contamination levels if discovered, would signify a significant breakdown in contamination control and would not be tolerated outside a controlled area. In practice areas are designated on a qualitative assessment of the hazard wherever there is any significant risk of contamination. A small level of airborne radioactive contamination potentially poses a higher radiological risk.

Contamination controlled areas must be accessed via change room or sub change room. Change rooms (and sub change rooms where practicable) should provide the following facilities: -

- A surmountable barrier to segregate clean and contaminated zones
- Space for storing and changing into protective clothing with bins for defective PPE
- Hand and clothing contamination monitoring equipment
- Equipment to monitor items that need to be removed
- Hand washing / showering
- A telephone to allow for notification of personal contamination

Contamination controlled areas C2 – surface contamination

The exposure of persons who would not normally work with ionising radiations in the course of their work is limited to an 'effective dose' below 1 mSv or an 'equivalent dose' less than the limit specified for 'other persons'. All 'significant doses' (1 mSv) to 'classified persons' must be assessed.

In deriving levels for declaring contamination controlled areas the following criteria are used: -

a) No person working outside a contamination controlled area should receive an effective dose in excess of 1 mSv in a year from ingestion, inhalation or skin irradiation.
b) No person should receive an equivalent dose to the skin in excess of 100 mSv in a year.

[The equivalent dose limit for other persons is 50 mSv however contamination will generally arise in close proximity to controlled areas to which persons not working with ionising radiations have limited access. 100 mSv was therefore taken as being reasonably conservative].

Derivation of surface contamination levels for C2 areas.

Maximum permissible levels of surface contamination in workplaces can be considered by 4 possible exposure pathways and are considered below: -

a) External irradiation of the skin;
b) Inhalation of resuspended radioactive material;
c) Ingestion of radioactive material picked up from surfaces; and
d) External irradiation from contamination of the skin at C2 clearance monitoring levels.

a. External irradiation from contamination on surface

Using an equivalent dose limit for skin of 100 mSv dose and assumed that the skin of an individual is in continuous contact with a surface during working hours (2000 per year) a derived limit DL for surface contamination can be obtained by calculating the surface contamination which results in a dose rate of 50 uSv per hour (i.e. 100 mSv/2000 hours). [Note that alpha radiation can be ignored when calculating this DL].

i.e. $\mathbf{DL_{irr} = 0.05/D_1}$

Where $\mathbf{DL_{irr}}$ is the surface activity in Bq/cm^2, which results in a skin dose of 100 mSv in 2000 hours, **0.05** = dose rate to the skin in mSv/h; and $\mathbf{D_1}$ = dose rate to the skin per unit surface activity (units: mSv/h/Bq/cm^2).

b. Limit on surface contamination resulting from inhalation of resuspended activity

Where surface activity is present, resuspension can take place resulting in a dose from inhalation. It is therefore necessary to limit surface contamination such that the effective dose from inhalation is less than 1 mSv [it should therefore be noted that above this level of surface contamination represents a level where resuspension could generate C3 airborne contamination levels]. The following formula can be used to calculate resuspended activity: -

$$DL_{resus} = DAC \times 10^{-6}/RF \times 0.01$$

Where DL_{resus} is the derived limit for removable surface activity in Bq/cm^2 which results in an air activity of DAC which, when inhaled, delivers an effective dose of 1 mSv in 2000 hours. RF is the resuspension factor (5×10^{-5} m^{-1}).

[Note that where the surface activity is not widespread within the work area, (which is normally the case in the nuclear sector) the DL_{resus} value can be increased by a factor of 10 to allow for dilution by uncontaminated air.] i.e. for localised contamination: -

$$\mathbf{DL_{resus} = DAC \times 10^{-6}/RF \times 0.1}$$

c. Ingestion of activity on surfaces

Persons working in normal plant areas are not restricted by the rules relating to smoking, eating, drinking etc that are designed to prevent ingestion of activity in contamination controlled areas. Surface contamination in uncontrolled work areas can therefore result in ingestion of activity picked up on hands or objects placed in the mouth e.g. pens. It is therefore necessary to restrict surface contamination such that the effective dose from ingestion of activity is less than 1 mSv. It can be assumed that a person ingests the activity on 10 cm^2 of skin/surfaces per day. A surface activity limit can then be derived using the formula: -

$$\mathbf{DL_{ing} = ALI_{ing}/(250 \times 10)}$$

Where $\mathbf{DL_{ing}}$ is the derived limit for surface activity in Bq/cm^2, on surface that could result in an effective dose from ingestion of 1 mSv. $\mathbf{ALI_{ing}}$ is the annual limit of intake from ingestion that results in an effective dose of 1 mSv and 250 is the number of working days in a year.

d. External irradiation from skin contamination

Acceptable clearance levels for activity on persons leaving supervised areas must be established such that the equivalent dose from activity fixed on the skin is less than 100 mSv. In this circumstance the dose could be received over the entire year (i.e. 8760 hours). The following formula can therefore be used to derive a limit for skin contamination

$$\mathbf{DL_{skin} = 0.0114/D_1}$$

Where $\mathbf{DL_{skin}}$ is the contamination on the skin in Bq/cm^2, that would result in an effective dose of 100 mSv, **0.0114** is the dose rate to the skin in mSv/h which delivers a dose of 100 mSv in the year and $\mathbf{D_1}$ = dose rate to the skin per unit surface activity (units: mSv/h/Bq/cm^2).

To limit the occurrences of 'personal contamination' (i.e. where skin contamination is above this 'clearance level') it is desirable that contamination limits for C2 area are not above the clearance level (taking into account operational considerations).

Using the above methodology, the various Derived Limits (DL) have been calculated for the most commonly encountered nuclides and the transuranic nuclides, (*the C2 and skin contamination limits for a number of commonly encountered radionuclides are given in attached Table 1*). Worked examples for P^{32}, Co^{60} and Am^{241} are also given below.

All the 4 surface contamination exposure pathway limits are derived: -

DL $_{irr}$ - Limit for total surface contamination (fixed and loose), which would result in an equivalent dose to the skin of 100 mSv (2000 hours exposure).
DL $_{resus}$ - The surface activity which if distributed over a large area could generate a significant air activity from resuspension (i.e. DAC). Note that for large area contamination, this value must be reduced by a factor of 10.
DL $_{ing}$ - Activity on the surfaces or the skin resulting in an effective dose from ingestion of 1 mSv.
DL $_{skin}$ - Activity on the skin that would result in an equivalent dose of 100 mSv (8760 hours).

The lower level of DL **resus**, **irr** and **ing** represents a limit for surface contamination above which a C2 area must be designated.

The maximum value of DL **skin** and **ing** represents a maximum value for surface contamination beyond which decontamination must be undertaken (this value also effectively sets a maximum limit for surface contamination allowable outside a C2 area).

Examining the data allows the following generalised limits for a C2 area to be stated: -

For Ac^{227}, U^{232} and isotopes of Am, Cm, Cf, Pu or Th	0.2 Bq/cm2 (notes 1 & 2)
For Pb^{210}, Ra^{228} and alpha emitters not otherwise specified	0.4 Bq/cm2 (note 2)
For radionuclides not otherwise specified	4 Bq/cm2 (note 3)
For C^{14}, S^{35}, Ca^{45}, Cr^{51}, Fe^{55} or Ni^{63}	40 Bq/cm2 (note 4)

1. *This derived value assumes that high toxicity alpha radionuclides, e.g. Ac^{227} and isotopes of Cm and Cf are NOT present in isolation. If these nuclides are found in isolation then the surface contamination limit should be reduced to 0.01 Bq/cm^2.*
2. *These values assume that the contamination is fairly localised e.g. over less than 1/10th of the surface area. Where widespread contamination is present an airborne hazard could be generated and these values should be reduced by a factor of ten.*
3. *Areas contaminated with tritiated liquor > 10^4 Bq.cm^2 or > $3E^3$ Bqml^{-1} will normally require designation as a contamination controlled area C2.*
4. *To retain these values it is necessary to introduce a lower clearance level for skin of 30 Bq/cm^2 for C^{14} and S^{35}.*

A contamination controlled area C2 shall be designated where the loose contamination level averaged over an area not exceeding 1000 cm^2 in the case of a floor, wall or ceiling, or 300 cm^2 in any other case, exceed the above specified values.

Within C2 areas there is the possibility of dispersion of radioactivity (especially for welding, drilling and abrasive tasks) leading to an airborne contamination hazard. Where widespread contamination in excess of 50 times the lower level for C2 area exists, air contamination measurements shall be made during work to confirm that conditions requiring the designation of a C3 area do not exist.

EXAMPLE CALCULATION Co^{60}

Co^{60}, Basic data: - $D_1 = 7.8E^{-4}$ mSv/h/Bq/cm^2 (radionuclide & radiation protection data handbook 98)
Dose coefficient (Sv/Bq) = $1.7E^{-8}$ for inhalation and $3.4E^{-9}$ for ingestion (ICRP 68)
ALI^{inh} (Bq) = 0.001/dose coefficient for inhalation
ALI^{ing} (Bq) = 0.001/dose coefficient for ingestion
(Where 0.001 is a 'significant' effective dose of 1 mSv (i.e. 0.001 Sv)
Thus $ALI^{inh} = 0.001/1.7E^{-8} = 5.88E^4$ Bq for inhalation (1mSv effective dose)
$ALI^{ing} = 0.001/3.4E^{-9} = 2.94E^5$ Bq for ingestion (1mSv effective dose)

i) DL $_{irr}$ irradiation of the skin for a dose of 100 mSv in 2000 h i.e. 0.05 mSv/h
DL $_{irr} = 0.05/D_1 = 0.05/7.8E^{-4} =$ **64** Bq/cm^2

ii) DL $_{resus}$ surface limit for resuspended surface contamination $DAC^1 = ALI^{inh}$ /2000x60x0.02
DAC^1 is the air activity, which results in an effective dose of 1 mSv in a year
2000 is the working hours in a year, 60 is minutes in an hour,
0.02 is the breathing rate for standard man in m^3 per minute.
$DAC^1 = 5.88E^4/2400 = 24.5$ Bq/m^3
Using the value of DAC^1 in the calculation above and a resuspension factor (RF) of 5 x 10^{-5}
The surface DL $_{resus}$ for **Co^{60}** based on an inhalation effective dose of 1 mSv is given by: -
DL $_{resus} = DAC^1$ x 10^{-4}/RF (10^{-4} is the conversion from Bq/m^2 to Bq/cm^2)
DL $_{resus} = DAC^1$ x $10^{-4}/5$ x $10^{-5} = 49.0$ Bq/cm^2 (**Note** that **490** Bq/cm2 is used – due to dilution factor of 10 for limited area contamination).

iii) DL $_{ing}$ from ingestion of activity on surfaces or the skin.
Annual intake from ingestion of activity on 10 cm^2 of skin per working day (250 days per year)
DL $_{ing}$ $ALI^{ing}/250$ x 10 = $2.94E^5/2500 =$ **118** Bq/cm^2

iv) DL $_{skin}$ direct irradiation from skin contamination
A doserate of 0.0114 mSv/h gives 100 mSv to the skin in 8760 hours.
DL skin = $0.0114/D_1 = 0.0114/7.8E^{-4} =$ **15** Bq/cm^2

From the above, the limiting **Co^{60}** derived level for declaring a C2 area (lowest of $_{irr}$, $_{resus}$ and $_{ing}$ is **64** Bq/cm2. The corresponding **Co^{60}** clearance level for the skin (lowest of $_{ing}$ and $_{skin}$) is **15** Bq/cm2.

Contamination controlled areas C3 – airborne contamination

The strategic decision for area designation must be whether a programme of personal monitoring for internal radiation, with an approved dosimetry service, is defensible. The methods applied to controlling work performed and building fabrication must be to remove and prevent exposure to airborne contamination at source, employers must not depend upon the evaluation of perpetrated exposure of staff. The principal objectives and criteria of a programme of routine monitoring of individual internal exposure is outside the scope of this paper; it would nonetheless need to consider compliance with managerial and regulatory requirements, contribute to the control and design of facilities, and support any requirements for accident dosimetry. Equally, at very low doses, this would be regarded as unwarranted. In particular circumstances, usually on an infrequent basis, some form of individual monitoring may be regarded as appropriate according to circumstances and usually for reassurance purposes.

Within the nuclear sector there is a need for derived airborne concentration (**DAC**) values based on air contamination levels for area designation in relation to internal radiation. To maintain doses from airborne activity to as low a level as reasonably practicable and to avoid the need for assessment of internal dose, intakes require to be controlled so as to be less than 1 mSv in a year. To meet this

requirement for designation of area where there is airborne contamination, where respiratory protection is usually required, the area must be designated when the effective dose from inhalation could exceed 1 mSv in a year.

An air activity (**DAC**) which, when inhaled, delivers an effective dose of 1 mSv in 2000 hours. This is equivalent to an exposure doserate equal to 0.5 $uSvh^{-1}$.
Given by: **DAC**[1] = ALI^{inh} /2000x60x0.02 (see above examples).

ALI^{inh} (Bq) = 0.001/dose coefficient for inhalation (Sv/Bq) (ICRP 68)
DAC[1] is the air activity, which results in an effective dose of 1 mSv in a year
2000 is the working hours in a year, 60 is minutes in an hour,
0.02 is the breathing rate for standard man in m^3 per minute, (i.e. 2400 m^3 y^{-1}).

Derivation of airborne contamination levels for C3 areas.

In deriving levels for designating contamination controlled C3 areas the following criteria is used: -

a) The **DAC**[1] value calculated for the derivation of DL $_{resus}$ (***see Table 1***) above is the activity, which will result in an effective dose from inhalation of 1 mSv to an unprotected person working inside the contamination controlled area. This therefore represents the C3 lower limit. The **DAC**[1] values for all radionuclides are provided in column 7 of ***Table 1***.
b) The levels of airborne concentration activity can only be averaged over a period that does not exceed 8 hours.

Examining the data allows the following generalised limits for C3 area to be stated:

1) Where a single radionuclide is present, the air concentration listed in ***Table 1*** (i.e. the **DAC** value), or
2) Where more than one radionuclide is involved, a quantity ratio of one, where the Quantity Ratio is defined as:

$$\text{Quantity Ratio} = \Sigma\, \mathbf{Q}_p / \mathbf{Q}_{lim}$$

Where $\mathbf{Q}_p$ is the quantity of a radionuclide and $\mathbf{Q}_{lim}$ is the value for that radionuclide given in ***Table 1***, or
3) For a mixture of unknown radionuclides, a value of 0.01 Bqm^{-3} (alpha) and 10 Bqm^{-3} (beta) is to be used.

It can be seen from ***Table 1*** that for some alpha emitters the value is actually less than 0.01 Bqm^{-3}; similarly for some beta emitters the value is lower than 10 Bqm^{-3}. However the isotopes involved are nearly all rather unusual and unlikely to be encountered in isolation. It is considered that setting the C3 lower boundaries as described above will offer an adequate degree of conservatism.

In assessing the air concentrations for C3 designation purposes, the contributions from radioactive isotopes of the noble gases argon, krypton and xenon can be disregarded since they present primarily a hazard from external radiation and the requirements for radiation controlled area designation will ensure that dose levels are not exceeded.

Taken from Table 1 - Comprehensive table of derived levels for use in delineation and designation of controlled areas due to surface and airborne contamination

5um inhalation dose coefficient

Nuclide	Ref 1. D1 mSv/h/Bq/cm2	ICRP 68 Inhalation Sv/Bq	IRRP 68 Ingestion Sv/Bq	1mSv ALI inh Bq	1mSv ALI ing Bq	DAC[1] Bq/m3	DL(resus) Bq/cm2	DL(irr) Bq/cm2	DL(ing) Bq/cm2	DL(skin) Bq/cm2	C2 Area Limit	Skin Contam Bq/cm2
H3	0	4.10E-11	4.20E-11	2.44E+07	2.38E+07	1.02E+04	203252	-	9524	-	9524	9524
C11	1.90E-03	3.20E-12	2.40E-11	3.13E+08	4.17E+07	1.30E+05	2604167	26	16667	6	26	6
C14	3.20E-04	5.80E-10	5.80E-10	1.72E+06	1.72E+06	7.18E+02	14368	156	690	36	156	36
F18	1.90E-03	9.30E-11	4.90E-11	1.08E+07	2.04E+07	4.48E+03	89606	26	8163	6	26	6
Na22	1.70E-03	2.00E-09	3.20E-09	5.00E+05	3.13E+05	2.08E+02	4167	29	125	7	29	7
Na24	2.20E-03	5.30E-10	4.30E-10	1.89E+06	2.33E+06	7.86E+02	15723	23	930	5	23	5
Al26	1.80E-03	1.40E-08	3.50E-09	7.14E+04	2.86E+05	2.98E+01	595	28	114	6	28	6
P32	1.90E-03	2.90E-09	2.40E-09	3.45E+05	4.17E+05	1.44E+02	2874	26	167	6	26	6
P33	8.60E-04	1.30E-09	2.40E-10	7.69E+05	4.17E+06	3.21E+02	6410	58	1667	13	58	13
S35	3.50E-04	1.10E-09	7.70E-10	9.09E+05	1.30E+06	3.79E+02	7576	143	519	33	143	33

Ref 1 - radiation protection dosimetry vol. 76 Nos. 1-2 1998

* Spontaneous fission - D1 figure based on Cf252.

COUNTRY SHEET - SWEDEN

CONTENTS

1. INTRODUCTION

The general principles of radiation protection in Sweden are laid down by the radiation protection act (1988:220 [1]). The designation of regulated radiation areas in Sweden is defined in the regulations established by the Swedish authorities (SSM) covering the "Basic provisions for the protection of workers and the general public in practices involving ionising radiation" (SSMFS 2008:51 [2]).

With regard to the nuclear industry, there are specific regulations covering workers in nuclear power plants (SSI FS 2000:10 [3]). Feedback from the benchmarking visit to the Ringhals nuclear power plant, CEPN report no. 282 [4], and the Ringhals safety rules [5], supplemented by information provided directly by the Ringhals radiation protection manager [6], contributed further information for this plant.

The quotation of these regulations come from their English translation as provided by SSM. Please refer to the official original texts if necessary.

2. DESIGNATION OF REGULATED RADIATION AREAS IN THE GENERAL REGULATIONS

2.1. Purpose and principle

The regulations, remain very vague with regard to the principle of classification of areas. It is just stated that an area is designated as controlled when workers are likely to receive the annual doses given in 2.4., or when there is a risk of contamination spreading (2.4.1).

2.2. Types of facility covered by the regulations

The radiation protection act [1] and the general regulations [2] cover all sources of ionising radiation and all sectors of activity.

2.3. Assessment of the nature and magnitude of the risk before designation

The general regulations do not stipulate a job study for risk assessment before area designation.

2.4. Area types

According to SSMFS 2008:51 (Chapter 4. Categorisation of workers and workplaces - Section 1) :
Categorisation of workers and workplaces shall be performed where workers may receive radiation doses in such a way that:
1. the annual effective dose amounts to 1 millisievert (mSv) or more, or
2. the annual equivalent dose to the lens of the eye amounts to 15 mSv or more, or
3. the annual equivalent dose to the hands, forearms, feet, ankles or the skin amounts to 50 mSv or more.

2.4.1. Controlled area

A controlled area is an area where workers are likely to receive the following doses:
- annual effective dose ≥ 6 mSv, or
- annual equivalent dose to the eye lens ≥ 45 mSv, or
- annual equivalent dose to the extremities and the skin ≥ 150 mSv.

These criteria correspond to the classification of workers in category A; the workplaces of category A workers must be designated as controlled areas.

SSMFS 2008:51 - Chapter 4.Categorisation of workers and workplaces –

Section 2. *The party that conducts the practice shall classify the workers into category A or B. A worker shall belong to category A if the likelihood is not negligible that:*
1. the annual effective dose amounts to 6 mSv or more, or
2. the annual equivalent dose to the lens of the eye amounts to 45 mSv or more, or
3. the annual equivalent dose to the hands, forearms, feet, ankles or the skin amounts to 150 mSv or more. Judging the likelihood in accordance with the first paragraph shall take into account the risk of mistakes or accidents that could imply radiation doses, including practices that normally do not imply high doses. Classification as category A shall be carefully considered for workers encompassed by Appendix 2.

Workers not belonging to category A shall belong to category B. For workers belonging to category B, surveillance of doses shall be performed to such an extent enabling demonstration that the classification in category B is correct.

Controlled area
Section 3 *A workplace where the workers may receive any of the annual radiation doses stated in Section 2 or from which radioactive contamination that is significant from a radiation protection point of view could be spread to nearby spaces shall be defined as a controlled area.*

The regulations provide a list of workers who should be classified in category A (refer to the table below – SSMFS 2008:51 Annexe 2). This list includes medical specialties.

Examples of practices where classification in category A shall be considered for workers

Other kinds of work not listed in the table may exist.

Practice	Workers whose belonging to category A shall be carefully considered
Medical, dental or veterinary radiology:	Anyone who takes part in work with fluoroscopy or more than 30exposures per week and stays with the patient not behind a radiation shield or anyone who takes part in work where the hands or some other unprotected part of the body is occasionally within or close to the primary beam.
Service or installation of equipment for which a licence is required:	Anyone who installs, performs service, changes radioactive sources, maintains or checks the equipment. This also applies to accessories if radiation is emitted during the work.
Intracavitary and interstitial therapy with sealed sources:	Anyone who handles radioactive sources or nurses patients during the treatment.
Radiotherapy except Grenz ray therapy:	Anyone who handles the sources.
Practices with open radioactive sources emitting gamma radiation:	Anyone who works with more than 100 MBq per step.
Practices with open radioactive sources emitting beta radiation:	Anyone who works with more than 10 MBq per step if the maximum β-energy is more than 0.3 MeV or anyone who works with more than 100 MBq per step if the maximum β-energy is between 0.1 and 0.3 MeV.
Nuclear activity:	Anyone who works within a controlled area.
Radiography except X-rays used within sealed boxes with interlock:	Anyone who takes part in the work.
Work with accelerators except shielded ones in industrial production lines:	Anyone who has access to the accelerator room.
Practices with sealed sources in industry or research:	Anyone who routinely takes part in work in positions where the dose rate exceeds 6 μSv/h or where it is possible to occasionally be within a radiation field having a dose rate exceeding 100 μSv/h.
Transport:	Anyone who routinely is in positions where the dose rate exceeds 6 μSv/h or for extended periods must be in positions where the dose rate exceeds 20 μSv/h.

2.4.2. Supervised area

Supervised areas are areas subject to these regulations but that are not controlled areas.

SSMFS 2008:51 - Chapter 4.Categorisation of workers and workplaces –

Supervised area
Section 8 *A workplace that is not a controlled area under Section 3 but to which these regulations apply shall be defined as a supervised area.*

2.5. Controlled area boundary characteristics

All controlled areas must be delineated. The regulations do not give further details of the type of delineation.

SSMFS 2008:51 - Chapter 4.Categorisation of workers and workplaces –

Section 5 *A controlled area shall be delineated and access to it restricted to authorised persons, by which is meant persons who have been sufficiently trained with respect to:*
1. the risks that the work in a radiation environment may imply,
2. the radiation protection measures to be taken, and
3. the local instructions that apply to the controlled area.

Temporary visitors may have access to a controlled area only if accompanied by an authorised person.

2.6. Controlled area access conditions

2.6.1. Training

Access to controlled areas is restricted to authorised persons, defined as persons who have received the required training on:
- the risks associated with working in a radiological environment
- the radiation protection measures to be taken
- the local rules.

(refer to quotation above of Chapter 4 – Section 5)

2.6.2. Personal equipment

The general regulations do not specify which personal equipment must be worn by personnel when they enter controlled areas. The Radiation Protection Law 2000: 264 § 8 stipulates that "*Persons engaged in activities with radiation, or work where such activity is performed, shall use the safety equipment and take any other measures that are required for the satisfactory functioning of the radiation protection."*

Visitors may have temporary access to a controlled area only if they are accompanied by an authorised person.

2.7. Specific measures to limit the contamination risk

The general regulations stipulate that areas where there is a risk of contamination must be designated as controlled areas, and that measures must also be taken to limit contamination outside controlled areas.

SSMFS 2008:51 - Chapter 4. Categorisation of workers and workplaces –

Section 3. *A workplace where the workers may receive any of the annual radiation doses stated in Section 2 or from which radioactive contamination that is significant from a radiation protection point of view could be spread to nearby spaces shall be defined as a controlled area.*

Section 6. *If there are radioactive substances in a controlled area which may contaminate surrounding areas, the party that conducts the practice shall take appropriate measures to prevent contamination by radioactive substances outside the area.*

2.8. Area marking

"A controlled area shall be marked with signs stating that it is a controlled area and the kind of radiation sources located within the area." (SSMFS 2008:51 - Chapter 4 – Section 7)

"A supervised area shall be marked with signs stating that it is a supervised area and what kind of radiation sources are located within the area. Supervised areas that are marked in accordance with previous regulations do not need to be marked once again". (SSMFS 2008:51 - Chapter 4 – Section 10)

3. NUCLEAR FACILITY RULES

3.1. Area types: Ringhals nuclear power plant

There are two types of area, controlled areas and non-designated areas, established on the basis of dose rates and surface and airborne contamination [5, 6].

3.1.1. Controlled areas defined according to dose rates

Ambient dose rate

- Blue area: dose rate < 25 μSv/h
- Yellow area: between 25 μSv/h and 1 mSv/h
- Red area: > 1 mSv/h

An area with a dose rate greater than 3 mSv/h is considered as a "high dose rate area". In addition, a hot spot can be defined when the dose rate close to a component or a circuit is higher than normal.

The upper value of the blue area has been defined so as not to exceed the limit of 50 mSv/year (2000 working hours at 25 μSv/hour).

3.1.2. Controlled areas defined according to surface contamination

For total β-γ:

- blue area: < 40 kBq/m^2
- yellow area: between 40 and 1000 kBq/m^2
- red area: > 1000 kBq/m^2

For total α:

- blue area: < 4 kBq/m^2
- yellow area: between 4 and 100 kBq/m^2
- red area: > 100 kBq/m^2

3.1.3. Controlled areas defined according to airborne contamination

- Blue area: 1 DAC
- Yellow area: 1-10 DAC
- Red area: > 10 DAC

The DAC is calculated on the basis of 20 mSv/year and 2000 working hours per year.

3.2. Delineation of controlled areas: Ringhals nuclear power plant

Barriers with ropes or chains are used in different situations with intention to mark or warn for a local change in the radiation environment. A barrier shall be considered as a wall or a closed door and may only be passed after performed prescribed protective actions. (Safety regulation at Ringhals § 9.4)

3.3. Controlled area access conditions

3.3.1. Nuclear industry

Before any work in a controlled area, all personnel, permanent or external workers, must be informed about radiation protection.

SSI FS 2000:10 Information and education § 6
All personnel, the permanent as well as external workers, shall be informed about radiation protection prior to work within a controlled area. Repetitive information shall thereafter be given at least every third year.
The information shall include a survey of the risks that are related to work with ionising radiation, how to act in case of an alarm, the local instructions and routines at the plant and practical aspects on radiation protection. [4]

3.3.2. Ringhals nuclear power plant

Entry to yellow areas and red areas requires prior authorisation from the radiation protection officer and a “radiation work permit”. Recommended equipment in the case of surface or airborne contamination is given in the tables below.

Protective equipment in areas designated according to beta – gamma surface contamination

Contamination kBq/m^2	< 40	40-1000	1000-4000	4000-10,000	> 10,000
Designation - Surface	Blue	Yellow	Red		
Minimum extra protective equipment		Yellow overshoes	Red overshoes Gloves	Red overshoes Gloves Hood Extra overall	Compressed air Full plasttic suit
Respiratory protection - particles			Half-face mask + P3	Full mask + P3	Compressed air Full plasttic suit
Respiratory protection - iodine			Full-face mask Iodine filter **	Full-face mask Iodine filter **	Compressed air Full plasttic suit
Designation – air*	Blue	At least Blue	Yellow		Red

* Designation based on surface contamination

** Applied in the case of exposed area greater than one square metre

Protective equipment in areas designated according to alpha surface contamination

Contamination kBq/m^2	< 40	40-100	100-400	400-1000	> 1000
Designation - Surface	Blue	Yellow	Red		
Minimum extra protective equipment		Yellow overshoes Gloves Hood Extra overall	Red overshoes Gloves Hood Extra overall	Red overshoes Gloves Hood Extra overall	Compressed air Full plastic suit
Respiratory protection			Half-face mask + P3	Full-face mask + P3	
Designation – air*	Blue	Lowest Blue	Yellow		Red

* Designation based on surface contamination

Protective equipment in areas designated according to airborne contamination

	DAC*	< 1	1-10	10-40	40-1000	> 1000
	Designation - air	Blue	Yellow	Red		
Airborne contamination - particles	Minimum extra protective equipment		Half-face mask + P3	Full-face mask + P3	Full mask + P3 Extra overall Overshoes Gloves Hood	Compressed air Plastic suit
	Designation – surface	At least Blue			At least Yellow	Red
Airborne contamination - iodine	Minimum extra protective equipment			Full-face mask + iodine filter	Full mask + iodine filter Overshoes Gloves Hood	Compressed air Plastic suit
	Designation – surface**	At least Blue			At least Yellow	Red
Airborne contamination - noble gases	Minimum extra protective equipment			Extra overall Hood	Extra overall Hood Compressed air Plastic suit	Compressed air Plastic suit
	Designation – surface	At least Blue			At least Yellow	Red

* The DAC is calculated on the basis of 20 mSv/year and 2000 hours of work per year.

3.4. Specific measures to limit the contamination risk

3.4.1. Nuclear industry

To limit the risks of contamination, eating and smoking are forbidden in controlled areas. Water from drinking fountains located in special areas may be consumed. All persons entering these special areas are checked for contamination. Only disposable cups filled directly from an automatic dispenser may be used. Within the area the β/γ surface contamination must be less than 40 kBq/m^2 and the α surface contamination must not exceed 4 kBq/m^2.

SSI FS 2000:10 Controlled area
§ 12 *Within a controlled area, consumption of food and smoking shall be forbidden. Water may be had from a drinking-fountain or be served within special areas according to what is stated in section 13.*
Prior the establishment of such an area, a description of the area and its use, including a programme for contamination check shall be sent in advance to the Swedish Radiation Protection Institute for judgement.

§ 13 *For a special area, mentioned in section 13, the following conditions shall apply.*
a) Before entrance of the area all persons shall be checked regarding contamination and must be free from external contamination according to the requirements in section 20.
b) Beverage must be served only by a disposable package or a disposable cup filled directly from an automatic machine.
c) The surface contamination within the area must not exceed 40 kBq/m2 as summed up for the most common beta- and gamma emitting nuclides, or must not exceed 4 kBq/m2 for alpha emitting nuclides. The conditions of contamination shall be regularly verified by measurements. [4]

3.4.2. Ringhals nuclear power plant

A first contamination monitor is located at the exit from the controlled area (equivalent to C1 in France) (calibrated using a 60 Co source at 100 kBq/m2) and a second monitor (equivalent to C2 in France) is calibrated using a 60 Co source at 40 kBq/m2.

During unit outage, two persons are assigned to assist at the controlled area exit.

At the exit from the Ringhals site, three Merlin Gerin detectors (equivalent to the C3 portal in France) are installed to check the contamination level of individuals (calibrated at 40 kBq/m2 at a distance of 50 cm).

There are also checks on goods vehicles (4 detectors) and equipment (monitor measuring total γ activity, calibrated at 1200 Bq with 60 Co source).

Another monitor for small items (keys, pens, etc.) is calibrated at 40 kBq/m2.

3.5. Area marking: Ringhals nuclear power plant

"*In combination with the barrier, signs shall be erected with information about radiation level, contamination level, prescribed protection equipment and other actions. In some cases the radiation protection personnel shall be contacted prior to access (Safety regulation at Ringhals § 9.4)*".

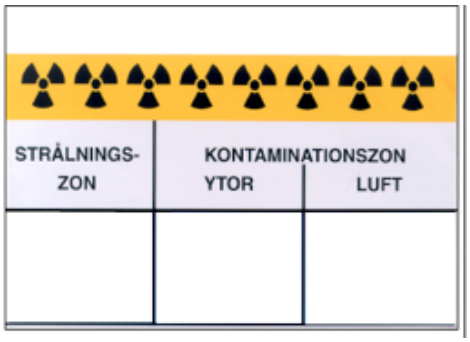
There are no specific restrictions on working in blue areas.

Accesses to yellow and red areas must be kept closed. Any access to these areas requires a specific work permit issued by the RP department.

"Radiation Danger" – indicates an area where the ambient dose rate is abnormally high. A permit from the RP department is required in order to access this area. If the sign is placed on a temporary barrier, the barrier must be considered as if it were locked.

"High irradiation level" – indicates that the dose rate around a component or a system is higher than normal. The sign gives the dose rate on the surface and at a distance of 1 m. The RP department must be contacted in the case of work on such components.

Low dose rate area



Sign used to indicate the area colour according to the dose rate, the surface contamination and the airborne contamination.

3.6. Transport of radioactive materials: Ringhals nuclear power plant

Outgoing equipment to be placed in the public domain is subject to an authorisation issued by a category B radiation protection officer. The equipment must have a contamination level < 40 kBq/m^2 and a dose rate at 1 m < 0.025 mSv/h.

When contaminated equipment exceeding the dose limits has to be transported on the site from one plant unit to another, a “special vehicle” is used. This vehicle is designated as a blue area for contamination and a yellow area for dose rate.

The rules applied for determining the shielding of equipment to be transported (refer to 3. Area types) depend on the contamination level and on the dose rate at 1 metre, as shown in figure 1 below.

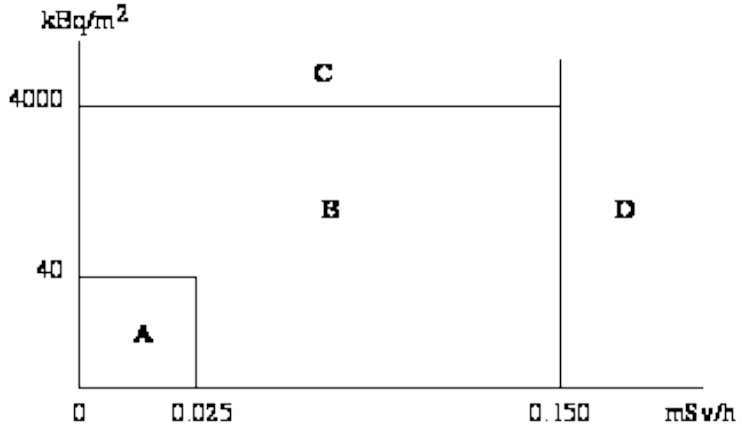


Figure 1. Zones determining equipment preparation for transport in the special vehicle

- In zone A, the equipment must be wrapped in plastic.
- In zone B, the equipment must be wrapped in plastic and placed in an IP2 carton.
- In zone C, the equipment must be wrapped in plastic and placed in a type A container.
- In zone D, the equipment must be wrapped in plastic and placed in a type A container. Special authorisation from the Head of Radiation Protection is required.

4. REFERENCES

[1] Radiation Protection Act (SFS 1988:220)

[2] The Swedish Radiation Safety Authority's regulations concerning basic provisions for the protection of workers and the general public in practices involving ionising radiation - SSM FS 2008:51

[3] The Swedish Radiation Protection Institute's Regulations on Radiation Protection of Workers Exposed to Ionising Radiation at Nuclear Plants SSI FS 2000:10

[4] CEPN report no. 282, Organisation of radiation protection at the Ringhals nuclear power plant in Sweden, April 2004

[5] Safety Regulations at Ringhals – Vattenfall 03/2011 1701177/15.0

[6] Personal communication from the Radiation Protection Expert of Ringhals

COUNTRY SHEET - SWITZERLAND

CONTENTS

1. INTRODUCTION

The requirements applied to the protection of workers and the public against ionising radiation in Switzerland are specified in the Radiological Protection Act (RPA) of March 1991 [1] and in its application rules specified in the Radiation Protection Ordinance (RPO) of 22 June 1994 [2]. The RPA applies to all activities and all facilities. The controlled area designation principles are set out in the RPO. It should be noted that the Swiss regulations do not provide for the establishment of supervised areas and do not recommend the division of controlled areas into sub-areas according to radiological risk.

For nuclear facilities, and more specifically nuclear power plants, the management of exposures at levels as low as reasonably practicable is governed by the principle of optimisation of radiation protection; the designation of regulated radiation areas is presented as a much less important measure than prior assessment of individual doses. Directive IFSN-G15/f for Swiss nuclear facilities [3] refers only to controlled areas for which "the licensee shall take the necessary measures to ensure effective planning of radiation protection", but does not give any criteria for the delineation, access rules and working conditions to be applied in such areas. Area designation and criteria are given only in a directive (in German) *Richtilinie für den überwachten Bereich der Kernanlagen und des Paul Scherrer Institutes HSK-R-07* of June 1995 [4]. To define the practices that can be observed in the Swiss nuclear power plants, data from a radiation protection benchmarking visit made by the CEPN to the Beznau nuclear power plant in 2006 are also used. [5].

In the medical sector, three ordinances define the criteria for the designation of radiation areas, covering accelerators used for medical purposes [6], medical use of sealed radioactive sources [7], and radiological facilities for medical purposes [8]. Some information on conditions of access to controlled areas (although not very detailed) is also given in Directive R-06-03 on dosimetric monitoring in hospitals, issued by the Office Fédéral de Santé Publique [9].

A specific ordinance defines the factors relating to area designation in non-medical facilities generating ionising radiation [10]; it applies for example to industrial radiography and radioscopy (fixed or mobile). The controlled area designation criteria are not defined, but information on delineation and on marking specific to controlled areas is given.

Lastly, with regard to unsealed sources, another ordinance gives some information on area delineation and area access conditions, for example for transport of sources [11].

The quotation of the Radiological Protection Act (RPA) and the Radiological Protection Ordinance (RPO) come from the English translation provided by the Federal Authorities of the Swiss Confederation. For the other document, the English translation has been made from the original text (French or German). Please refer to the official original texts if necessary.

2. DESIGNATION OF REGULATED RADIATION AREAS IN THE GENERAL REGULATIONS

The Radiation Protection Act (RPA) of 22 March 1991 [1] applies to all activities and all facilities. It is supplemented by the radiation protection ordinance (RPO) of 22 June 1994 [2], which defines the rules for application of the act. The principle of establishment of controlled areas is laid down in the Ordinance (Article 58).

Chapter 5 Use of radioactive facilities and sources
Section 1 Controlled areas
Art. 58

1. *The licence holder must establish controlled areas to limit and monitor radiation exposure.*
2. *Controlled areas are to be clearly delimited and marked with signs as specified in Annex 6.*
3. *The licence holder must control access to and presence in controlled areas.*
4. *Within the scope of their responsibilities, the FDHA and DETEC shall issue the necessary regulations governing behaviour in controlled areas.*

2.1. Purpose and principle

The purpose of the designation of regulated radiation areas is to "limit and control exposure to radiation".

It should be noted that in Switzerland an annual effective dose less than 100 µSv received in the context of an occupational activity (or less than 10 µSv/year excluding occupational activity) is considered as optimised *de facto* (negligible level).

The classification of areas can also be considered to satisfy in part the obligation of the employer to inform workers about the radiation doses that they must expect to receive during their activity *[RPO Art. 33]*.

2.2. Types of facility covered by the general regulations

The RPA[1] and the RPO [2] are applicable to all sectors of activity (excluding the handling of raw materials composed of natural nuclides delivering a dose less than 1 mSv per year).

2.3. Area types

The main text of the RPO only stipulates the requirement to designate controlled areas (Art. 58). Appendix 1 of the RPO defines the following as controlled areas:

a. *Working areas for the handling of unsealed radioactive sources whose activity exceeds the licensing limit values presented in Annex of the ordinance;*
b. *Areas in which air concentrations may exceed 1/20 of the guidance values[10] specified in Annex of the ordinance[11]*
c. *Areas in which surface contamination may exceed the guidance values specified in Annex of the ordinance*
d. *Areas in which people may accumulate an effective dose of more than 1 mSv per year as a result of external exposure;*
e. *Areas in which equipment is operated without a full protection system;*
f. *Areas designated as such by the supervisory authority.*

The RPO does not make any mention of possible division of controlled areas into sub-areas.

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10 Guidance value : General term for a value which is derived from a limit; exceeding this value triggers certain measures, while compliance with it also ensures compliance with the associated limit.

11 The guidance values for airborne contamination (in Bq/m^3, for 2400 m^3 inhaled in 2000 hours) and surface contamination (Bq/cm^2, averaged over 100 cm^2) are calculated with reference to effective doses of 20 mSv/year and 0.5 mSv/year, respectively. (For further details, refer to RPO Appendix 3.)

Additional information on permissible doses outside controlled areas is given in the article covering facility shielding (Art. 59 of the RPO):

1. The room or area in which stationary radiation generators or radioactive sources are operated or stored shall be designed and shielded in such a way that, taking into account the frequency of use:

a. in places situated within the premises but outside controlled areas, where non-occupationally exposed persons may be present, the local dose does not exceed 0.02 mSv per week; in places where people are not continuously present, this value may be exceeded by up to a factor of five;

b. in places outside the premises, the off-site limits specified in Article 102 are not exceeded[12]*.*

2. With the agreement of the supervisory authority, in rarely occupied places outside controlled areas within continuously monitored premises, where exceeding the dose limit specified in Article 37 (1 mSv/year) is prevented by appropriate measures, the ambient dose rate may be up to 0.0025 mSv per hour.

2.4. Controlled area marking

The RPO (appendix 6) defines the signs and the minimum information that must be given at the entrance to a controlled area, according to the radioactive sources used:

1. Unsealed radioactive sources:

1. *the most radiotoxic nuclide and its maximum activity;*
2. *the classification of the working area (type A, B or C);*
3. *the maximum degree of contamination caused by loose contamination on surfaces, expressed in Bq/cm2 or as the number of guidance values for the nuclide concerned;*
4. *the ambient dose rate in mSv per hour in the accessible area, if appropriate;*
5. *details of the protective clothing and protective measures required;*
6. *the hazard warning symbol.*
7.

2. Sealed radioactive sources:

1. *the most radiotoxic nuclide and its maximum activity, or the activity of and nuclide with the highest-energy gamma radiation;*
2. *the ambient dose rate in mSv per hour in the accessible area, if appropriate;*
3. *the hazard warning symbol.*
4.

3. Equipment (e.g. X-ray equipment, accelerators):

1. *the designation of the equipment;*
2. *the type of radiation (e.g. electrons, X-rays, neutrons, where not apparent from the equipment designation);*
3. *the ambient dose rate in mSv per hour in the accessible area, if appropriate;*
4. *the hazard warning symbol.*

For unsealed sources, in addition to the sign at controlled area entrances specified in the appendix of the RPO, the ambient dose rates and the increased contamination produced in the area must be given. If necessary, stays in these areas must be specifically controlled and their durations limited.

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[12] *Art. 102 – Off-site limits :*
1. The yearly average concentration of airborne radioactive substances off-site shall not exceed a three-hundredth of the guidance value specified in Annex 3 Column 11
2. The weekly average concentration of radioactive substances in publicly accessible waters shall not exceed a fiftieth of the exemption limit for specific activity specified in Annex 3 Column 9
3. Direct radiation off-site must not lead to ambient doses exceeding 1 mSv per year in premises where people live, spend time or work, or 5 mSv per year in other areas.

3. NUCLEAR INDUSTRY RULES

3.1. Rules applicable to the nuclear industry in Swiss directives

3.1.1. General principles

A Swiss federal nuclear safety inspectorate (IFSN) directive applicable to the nuclear industry (IFSN-G15/f [3]) refers only to the planning of radiation protection in controlled areas, without giving further details of the area delineation criteria. Another directive, in German (*Richtilinie für den überwachten Bereich der Kernanlagen und des Paul Scherrer Institutes HSK-R-07*), published in June 1995 [4], gives details of area delineation criteria and conditions of access to controlled areas on nuclear sites.

3.1.2. Assessment of the nature and magnitude of the risks

The IFSN directive on the radiation protection objectives applicable to nuclear facilities stipulates, with regard to persons occupationally exposed to radiation, that "the licensee shall take the necessary measures to ensure effective planning of radiation protection, taking into account the principle of optimisation. These measures take into consideration the individual and collective doses associated with work in controlled areas and in radiation fields and are accompanied by dose planning objectives."

Directive IFSN-G15/f
4.1.2. Dose planning objectives
a. The licensee shall define dose planning objectives. These are deduced from empirical values obtained during optimised work and show what can be achieved through application of good technique and a suitable working method.
b. For companies in which no dose greater than 2 mSv per year can occur, the customary information according to directive IFSN-B02 is sufficient to define the dose planning objectives.
c. For facilities in which individual doses greater than 2 mSv per year can occur in normal operation, a radiation protection quality management system, in accordance with article 136, paragraph 6 of the RPO, is required.
d. If the radiation protection planning of a job involves a collective dose of more than 50 person-mSv, the radiation protection plan shall be submitted to the IFSN, in accordance with directive IFSN- B03, chapter 4.3.
e. Before a scheduled outage (for example for overhaul, refuelling or repair), nuclear power plants shall establish dose planning objectives for the associated works. These objectives must be announced in good time, in accordance with directive IFSN-B03, chapter 4.1. They must be submitted to the IFSN on request, with their deduction. They are based on:
- values drawn from experience with similar work done in the facility in question or in a similar facility;
- the current radiological condition of the facility;
- international experience;
- optimisation procedures (comparison of different work processes and protection measures).
f. Nuclear power plants shall, at the beginning of the year, define the dose planning objectives for operation in production mode. These objectives are based on the volume of work known at that time, values from experience in previous years, and possibly on optimisation measures. They will be adjusted in the case of substantial changes in the volume of work or changes in radioactive inventory.
g. In the case where radiation protection plans for operation in production mode and for the scheduled outages (for example for overhaul, refuelling or repair) entail an annual collective dose greater than 1500 person-mSv, the IFSN will conduct a detailed review of the plan and, if necessary, require other optimisation measures.

With regard to radiation protection objectives for non-exposed persons, the directive refers to the Radiation Protection Ordinance RPO.

Directive IFSN-G15/f
4.2. Radiation protection objectives for persons not occupationally exposed to radiation within the company premises
For persons not occupationally exposed who spend time within the company premises, protection against direct radiation is regulated in article 59 of the RPO. For the limitation of airborne and surface contamination within the company premises, the guidance values given in chapter 6.1 of directive HSK- R-07, corresponding to 0.05 CA and 1 CS, respectively, are applicable. For the individual dose, the annual limit value is 1 mSv, in accordance with article 37 of the RPO.

3.1.3. Area delineation

The directive applicable to the nuclear industry defines supervised areas and stipulates that any controlled area must be located within a supervised area.

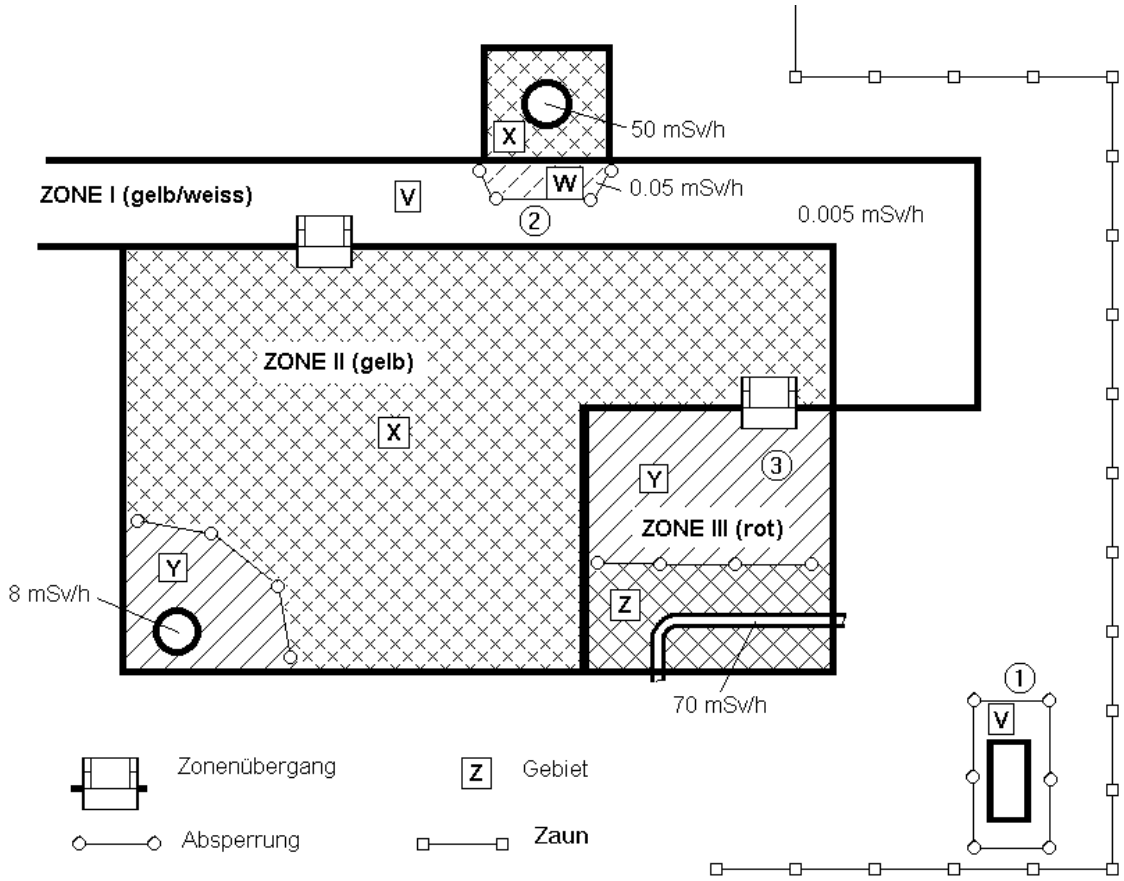
In addition, the controlled areas must be defined in closed premises. The controlled areas are classified according to the level of surface and/or airborne contamination (areas I and IV). Within controlled areas, sectors are defined according to external exposure (sectors V to Z).

3.1.3.1. Sector designation criteria with respect to external exposure risk

- Regulated radiation area outside controlled area: 20 µSv/week (0.12 µSv/h) in areas where non-classified workers may stay, or 100 µSv/week (0.6 µSv/h) in transit areas where the dose rate is less than 1 µSv/h.

- Sector V: dose rate < 0.01 mSv/h,
- Sector W: 0.01 mSv/h < dose rate < 0.1 mSv/h,
- Sector X: 0.1 mSv/h < dose rate < 1 mSv/h,
- Sector Y: 1 mSv/h < dose rate < 10 mSv/h,
- Sector Z: dose rate > 10 mSv/h.

It should be noted that the directive gives an example of designation (diagram below), with explanations of area designations and physical delineation, for each particular location.



German/English glossary (in alphabetical order): Absperrung = barrier, Gebiet = sector (V, W, X, Y or Z), gelb = yellow, rot = red, weiss = white, Zaun = fence, Zonenübergang = transition area

① Temporary storage area for an irradiating component: area must be closed because of increased dose rate.

② In the corridor, which is a V sector, the dose rate is increased at one location by a component in the adjacent room. This location must be closed.

③ This area is a red contaminated area III and a dose rate area Y. At the back of the room, a pipe generates a higher dose rate resulting in a Z designation. A barrier must be installed in the room to separate the two sectors.

According to the directive, the surfaces of the walls, floors, ceilings and equipment in controlled areas must be easy to decontaminate.

Areas where persons stay for a long time but which do not contain any sources, such as control rooms and waiting rooms, must be shielded so that the dose rate does not exceed 1 μSv/h.

3.1.3.2. Designation criteria with respect to the contamination risk

The criteria for surface contamination, CS, and airborne contamination, CA, correspond to the guidance values defined in the appendix of the RPO for each radionuclide.

	Surface contamination	Airborne contamination
Area I: yellow area with low probability of contamination	$K_0 < 1$ CS	$K_1 < 0.1$ CA
Area II: yellow area	1 CS $< K_0 <$ 10 CS	$K_1 < 0.1$ CA
Area III: red area	10 CS $< K_0 <$ 100 CS	0.1 CA $< K_1 <$ 10 CA
Area IV: red area	$K_0 > 100$ CS	$K_1 > 10$ CA

3.1.4. Access conditions in the nuclear industry

Personnel entering a controlled area must have received training and information on the risks to which they are exposed. A suitable change room must be provided. The access doors must be subject to appropriate control. Accesses to emergency exits leading to non-controlled areas must be marked so as to prevent unauthorised entry into controlled areas. The pressure in the controlled area must be lower than the pressure in the adjacent non-controlled area.

Protective clothing regulations

- Area 0: no regulation
- Area I: coat, area-specific overshoes or shoes
- Area II: coverall, area-specific overshoes, gloves
- Area III: coverall with red marking, area-specific clothing under the coverall, area-specific overshoes, protective hood, gloves, dust mask available
- Area IV: coverall with red marking, area-specific clothing under the coverall, protective hood, gloves, protective boots, protective mask with absolute filter.

Area access conditions and stay times

- Areas 0, I, II: no additional access restrictions, and time complying with the ALARA concept
- Area III: access after authorisation given in accordance with the operating rules, possibly under the control of the RP department, stay time may be limited by airborne contamination
- Area IV: access after authorisation given in accordance with the operating rules and only under strict control by the RP department, stay time limited according to occupational health considerations.

Access conditions according to dose rate, wearing an electronic dosimeter

- Sector V: no access restriction, and time complying with the ALARA concept
- Sector W, X: access only for personnel authorised according to the internal rules, and limited stay time
- Sector Y: access only for personnel authorised according to the internal rules under control by the RP department or a representative, and very limited stay time
- Sector Z: access restricted to personnel authorised according to the internal rules and under strict control by the RP department, after production of a work plan, and very strictly limited stay time.

3.2. Nuclear industry rules: Beznau nuclear power plant

A benchmarking visit by the CEPN in 2006 to study the radiation protection organisation at the Beznau power plant (report 06/23 [7]) clarified some specific points concerning classification of areas in this plant.

3.2.1. Rules in the Beznau nuclear power plant

3.2.1.1. Classification according to contamination levels

The controlled area is divided into five categories according to surface and volume contamination levels. The designation criteria for these categories and the RP measures according to category are summarised in the table below. The strictest criterion takes precedence in area designation. The Beznau power plant uses a specific unit, the "Richtwerk" (RW), which is equivalent to:

- 3 Bq/cm^2 of Co-60 equivalent for surface contamination,
- 500 Bq/m^3 of Co-60 equivalent for volume contamination.

Area	Surface contamination (RW)	Volume contamination (RW)	Specific radiation protection measures
0	Low	Low	None
I	≤ 1	≤ 0.1	None
II II-S[13]	> 1 - 10	≤ 0.1	Area delineation Twice-daily measurement of surface contamination outside and inside the area
III	> 10 - 100	> 0.1 – 1	Same as II During work, contamination measurements every 2 hours
IV	> 100	> 1	Same as II During work, contamination measurements every hour

Note: Most of the controlled area is category I, the reactor cavity is category III and the fuel transfer channel to the cavity is category IV.

At Beznau, areas I and II are marked yellow, areas III and IV red.

[13] Area II-S is a specific area of the RB. Slightly different clothing must be worn than in area II.

3.2.1.2. Classification according to dose rate

In addition to the classification according to surface and volume contamination, the controlled area is also divided into five categories according to the ambient dose rate. The categories and the specific RP measures are summarised in the table below.

Area	Dose rate (μSv/h)	Specific RP measures
V	≤ 10	None
W	> 10 – 100	None
X	> 100 – 1,000	Delineation (yellow "*Radioactive*" paper) Measurement in contact and at 1 m or at area boundary with posting of measurements
Y	> 1,000 – 10,000	Same as X No entry without an RP Work supervised by an RP
Z	> 10,000	Locked area (if possible, otherwise area delineation) Only RPs have the key Dosimetry must be estimated before any work

3.2.2. Conditions of access to areas designated according to contamination criteria

Specific clothing must be worn according to the category of the area. In all cases, any person entering the controlled area must wear overshoes and a white coverall. Use of underwear, T-shirt and socks provided by the plant when entering the area is advised but not compulsory. This means that persons may enter the controlled area in civilian clothes. The clothing to be worn according to area category is defined in the table below.

Area	Clothing
I	Civilian clothing, white coverall and overshoes OR KKB[14] underwear, KKB T-shirt, KKB socks, white coverall and area shoes
II	KKB underwear, KKB T-shirt, KKB socks, white coverall, area shoes, **blue overboots** and **cotton gloves** (rubber gloves can be used for wet area work)
II-S	(in the RB) – same as area II plus a **cap**
III	KKB underwear, KKB T-shirt, KKB socks, **red** coverall, area shoes, blue overboots, cotton gloves and **rubber gloves**, **cap** and **dust mask**
IV	KKB underwear, KKB T-shirt, KKB socks, red coverall, boots and overboots, cotton gloves, rubber gloves plus **a second layer of rubber gloves**, cap, **air mask and suit**

It should be noted that, for work in a category IV area, the type of respiratory equipment and suit depends on the contamination level. For this type of clothing, external help is necessary for operator dressing and undressing.

[14] KKB: Kernkraftwerk Beznau (Beznau nuclear power plant)

3.2.3. Marking

3.2.3.1. Marking of areas designated according to dose rate

In the Beznau nuclear power plant, the areas designated according to dose rate, in contrast to the areas designated according to contamination, are not clearly marked. The measured dose rates (ambient, contact, at 1 metre, etc.) are posted on signs located around the various contamination areas. The ambient dose rates are also given on the controlled area plans posted at various places in the reactor building and in the nuclear auxiliary building, depending on whether the unit is operating or shut down. The various controlled area categories (sectors V, W, X, Y, Z) are symbolised on these plans by different colours. However, in the field this colour-coding is not used on the markings to identify the different sectors.

3.2.3.2. Marking of areas designated according to contamination

Controlled areas must be marked by signs giving the category of each area where there is a category change in a given room or between rooms. The signs must have specific colours to help identify the category. Areas I and II are marked in yellow, while areas III and IV are marked in red.

3.2.4. Specific measures to limit the contamination risk

Hand-washing is compulsory at exits from the controlled areas. β, γ detectors are provided for checking hands and feet. Changing and shower facilities are also provided.

It should be noted that at the time of the visit (2006) there was no control scanner at the site exit.

Checks are also performed on tools, materials, laundry and vehicles entering and leaving sites.

4. RULES IN THE MEDICAL SECTOR

4.1. Specific Ordinances

There are three specific Ordinances applicable to the medical sector, defining the criteria for designating areas in several fields of activity:

- Ordinance on radiation protection for electron accelerators used for medical purposes (OrAc), 15 December 2004 [6],
- Ordinance on medical use of sealed radioactive sources (OSRM), 15 November 2001 [7],
- Ordinance on medical radiological facilities (Ordinance on X-rays), 20 January 1998 [8],
- Ordinance on the use of non sealed radioactive sources, 21 November 1997 [11].

4.2. Area delineation

4.2.1. Electron accelerators

OrAc Section 3: Design-related radiation protection, Art. 11
Accelerators must be operated in an irradiation room. The control system must be located outside the irradiation room. The irradiation room must be considered as a controlled area.
In sectors contiguous with the irradiation room, the following ambient doses must not be exceeded:
- 0.02 mSv per week at any location outside the controlled area,
- 0.1 mSv per week at any location inside the controlled area.

At locations outside the controlled area where a long stay is not planned and where no work station is installed, an ambient dose five times greater than the dose given above is permitted. In particular, this concerns waiting rooms, change rooms, archive rooms, stores, cellars, toilets, corridors, staircases, lift shafts, pavements, streets, green spaces and parks. The ambient dose is not subject to any limitation at locations where nobody can stay during accelerator operation.

4.2.2. Sealed radioactive sources

OSRM Chapter 2: Architectural radiation protection measures and outfitting, Art. 6, Art. 9, Art. 11, Art. 12

Irradiation units must be operated in an irradiation room. The control system must be located outside the irradiation room. The irradiation room must be considered as a controlled area.

In rooms where medical radioactive sources are applied manually (operating theatres, for example), movable shielding must be available, in addition to adequate shielding of the room perimeter according to art. 6. The movable shielding must be designed to ensure that the ambient dose rate outside the shielding does not exceed 25 μSv/h.

In the rooms of patients undergoing radiotherapy, movable shielding should be installed, in addition to adequate room perimeter shielding according to art. 6. Stationary shielding at least 110 cm high should be installed along the patient's bed. It must be designed to ensure that the ambient dose rate outside the shielding does not exceed 25 μSv/h.

In sectors contiguous with rooms where medical radioactive sources are used or stored, the following ambient doses must not be exceeded at any location:

a. 0.02 mSv per week at locations where individuals not occupationally exposed to radiation may stay for long periods or at locations where the stay is not under the control of the licensee;
b. 0.1 mSv per week at locations accessible only by individuals occupationally exposed to radiation or which are not intended for a long stay.

The ambient dose is not subject to any limitation at locations where nobody can stay while medical radioactive sources are in use.

4.2.3. Medical radiological facilities

Ordinance on X-rays Chapter 2: Construction-related radiation protection, Art. 6
Rooms in which radiological facilities are used must be shielded so that, according to the planned operating parameters, the ambient dose rate does not exceed 0.02 mSv per week at any location outside where persons not occupationally exposed to radiation may stay for long periods.

The ambient dose rate must not exceed 0.1 mSv per week in contiguous areas where persons not occupationally exposed to radiation do not stay for long times. These areas are waiting rooms, change rooms, toilets, corridors, staircases, lift shafts, pavements, streets, green spaces, parks, rooms without fixed work positions such as archives, stores and cellars.

The shielding in the radiology room and its perimeter must be designed so that the ambient dose rate does not exceed 0.1 mSv per week at any location in the contiguous areas where only occupationally-exposed persons stay.

The ambient dose is not subject to any limitation at locations where nobody can stay while the radiological facility is operating.

4.3. Access conditions

According to Ordinance on radiation protection for electron accelerators used for medical purposes (OrAc), Art 15 – Information and training of workers:

1. Before starting to work; the workers newly employed are informed by the radiation protection expert about the radiation protection rules to be applied
2. Cleaning personnel are authorised to work in controlled areas only if they have received instructions from a person trained in radiation protection.

According to OFSP Directive R-06-03 on dosimetric monitoring in hospitals [9], access to controlled areas is restricted to occupationally-exposed personnel and to patients undergoing therapy, and must be controlled in consequence. Persons who stay in operating theatres or in other controlled areas as part of their practical training must wear a dosimeter.

5. RULES IN NON-MEDICAL RADIOLOGICAL FACILITIES

A specific Ordinance on ***non-medical ionising radiation production facilities*** provides information on area designation in non-medical ionising radiation production facilities [10]. Controlled area designation criteria are not discussed, but information is given on delineation and on specific marking.

5.1. General principles

Non-medical radiological facilities are understood to include:

- equipment or apparatus producing photon and particle radiation of energy greater than 5 keV
- instruments, equipment and apparatus emitting stray ionising radiation in cases where the dose rate at 10 cm from the surface exceeds 1 μSv per hour.

The Ordinance [10] gives information on the controlled area boundary characteristics and the related signs. Area delineation criteria are not defined; reference is made to article 58 of the general regulations for designation of places as controlled areas. In article 9 of section 3, it is stipulated that facilities without full shielding must be located in controlled areas. No particular requirement is cited for facilities with full shielding.

Section 3 Facility location and shielding
Art. 9 Location
1. Facilities that do not have full shielding shall be placed in irradiation rooms conforming to art. 60, para. 2, RPO, or in delineated sectors. These locations are considered as controlled areas according to art. 58 of the RPO.
2. No particular requirement is defined for the location of facilities with full shielding.

5.2. Area boundary characteristics

Article 10 of the Ordinance determines the shielding and the design of the areas in which non-medical radiological facilities are located, taking dose rates into account.

Section 3 Facility location and shielding
Art. 10 Facility shielding
1. The shielding of irradiation rooms or the dimensions of delineated sectors shall be established on the basis of the operating parameters so that the following dose rates are not exceeded:
a. 0.02 mSv per week: in rooms located outside controlled areas;
b. 0.1 mSv per week: at locations, outside controlled areas, that are not intended for long stays;

c. 0.1 mSv per week: at locations, inside controlled areas, where only persons occupationally exposed to radiation may stay. In addition, the maximum dose rate permitted at accessible locations shall not exceed 100 μSv per hour.

2. No dose rate limit is applied at locations where no person can be present during facility operation.

It is also stated, in art. 11, that architectural radiation protection drawings of facilities that do not have full shielding must be sent to the Office Fédéral de Santé publique (Federal Public Health Office).

Appendix 3 of the Ordinance, referring to fixed facilities located in irradiation rooms and intended for radiography, stipulates that adequate provision must be made to prevent access to the irradiation room while the facility is operating, without giving further details.

Appendix 3.
1. Fixed facilities located in irradiation rooms and intended for production of radiological images (radiography)
1.1 Operation of the facility shall be possible only when accesses are locked or secured. During operation of the facility, adequate provision shall be made to prevent access to the irradiation room. It shall be possible to exit from the irradiation room at any time.

Appendix 3 also specifies certain area boundary characteristics in the case of mobile facilities.

Appendix 3. Use of mobile facilities
3.1. The following equipment should be available when using mobile facilities:
a. equipment to prevent access (posts, ropes, etc.)
c. shielding equipment if needed (shield panels, for example);
(...)
3.4. Access to the location where the radiological examination takes place (controlled area) shall be prohibited from all sides up to the safety distance judged necessary. When the facility is tested, checks are made to ensure that the permitted dose rate is not exceeded at the safety distance, taking into account the planned weekly operating time.

5.3. Marking

A warning light must be placed on the facility to indicate emission of radiation and must be easily visible from the boundaries of the controlled area. This light must be accompanied by warning signs and a designation according to appendix 6 of the general regulations (RPO).

Art. 5 Warning devices
1. Emission of radiation shall be indicated clearly by at least one warning light placed on the facility.
2. The warning lights shall be easily visible from the boundary of the controlled area all around the facility.
3. Facilities that do not have full shielding and are operated at locations other than inside an irradiation room shall not be operated when the warning lights are faulty.
4. The facilities shall be marked with a warning sign and a designation according to RPO appendix 6.

5.3.1. Specific case of fixed facilities in irradiation rooms intended for production of radiographic images

Information on marking of specific facilities is given in appendix 3. It is stipulated that the operating condition of radiography facilities must be clearly indicated at each entrance to the irradiation room, either by a warning light or by a flashing light.

Appendix 3. Fixed facilities in irradiation rooms intended for production of radiographic images

1.2. The operating condition of the facility shall be indicated in the irradiation room, at all entrances to the room, and close to the control system. Inside the irradiation room, the operating condition must be indicated either by a rotating warning light or by a flashing light. It shall be possible to monitor the operation of the warning lights from outside the controlled area.

5.3.2. Specific case of mobile facilities

Appendix 3 states that warning signs and flashing lights must be placed around mobile facilities, without giving details of such marking.

5.4. Specific measures to limit the contamination risk

Appendix 4 of the Ordinance on non-medical ionising radiation production facilities covers the control of the contamination risk in electron beam welding facilities.

Appendix 4
Electron beam welding facilities
1. After overhaul or modification of an electron beam welding facility, a check should be carried out to ensure that there is no radiation leakage, in particular at the vacuum isolation seals and the spacers.
2. Replacement of lead glass viewing windows by normal glass windows is not permitted. A replacement window shall have at least the same lead-equivalent attenuation factor as the original window.

6. UNSEALED SOURCES

Some points concerning the use of unsealed sources, in particular regarding area boundaries, are clarified in an Ordinance: ***Ordinance on the use of unsealed radioactive sources*, 21 November 1997 [11]**. This Ordinance is applicable to all areas of activity using unsealed sources.

6.1. Area delineation (room sectorisation)

Working areas must be defined for work with unsealed radioactive sources if source activity exceeds the authorisation limit defined in the appendix according to the radionuclide used. *[RPO, Art.69 [2]];*

The working areas must be established in separate rooms, used exclusively for this purpose.

The working areas are designated by type, according to the activities handled per operation or per day:

- Type C: An activity from 1 to 100 times the licensing limit specified in the Annex 3 Column 10 of the RPO
- Type B: An activity from 1 to 10 000 times the licensing limit specified in Annex 3 Column 10 of the RPO
- Type A: An activity from one times the licensing limit to an upper limit that shall be defined in the licensing procedure

Ordinance on the use of unsealed radioactive sources, Appendix 2: Guidance values for ambient dose rates as practical monitoring variables

The external irradiation dose limit values for persons, defined by the radiation protection Ordinance, are considered to be complied with when the ambient dose rate guidance values (µSv/h) given in the table are not exceeded (the guidance values must be considered as "net" values, i.e. after subtraction of the natural background).

Location	Location where persons stay	Guidance value (µSv/h)
Inside a controlled area		
Inside a working area	- Accessible locations with stay limits and corresponding marking	no
	- Accessible locations without special stay limits	< 10
	- Fixed work places	< 5
Outside a working area	- In rooms contiguous with working area	< 2.5
Inside or outside working area	- Locations not intended for long stays, such as toilets, waiting rooms, change rooms, archiving and storage rooms without work place, , counters, corridors, staircases, lift shafts, in a patient's room: behind fixed shielding along the bed	< 25
Outside a controlled area		
Within the company boundary	- Locations intended for long stays, such as patients' rooms in hospitals, company personnel apartments, guest accommodation	< 0.1
	- Fixed work place	< 0.5
	- Locations not intended for long stays, such as toilets, waiting rooms, change rooms, archiving and storage rooms without work place, counters, corridors, staircases, lift shafts and other accessible spaces	< 2.5
Outside the company boundary	- In general, including rooms where persons live, stay or work	< 0.1
	- Locations not intended for long stays, such as green spaces, paths and streets, work sites	< 0.5

6.2. Access conditions and requirements

Ordinance on the use of unsealed radioactive sources, Chapter 2 Construction and outfitting requirements, Section 1 Work sectors and storage locations; Art. 5

Each work sector or group of intercommunicating work sectors within a given controlled area must have at least one suitable instrument for measurement of contamination and, if necessary, dose rate available at all times.

A suitable hand scanner must be installed permanently at each exit from type C work sectors, and a suitable hand and foot scanner at each exit from type B and A work sectors.

Ordinance on the use of unsealed radioactive sources, Chapter 2 Construction and outfitting requirements, Section 1 Work sectors and storage locations; Art. 6

A change room for changing shoes and clothes must be provided before the entrance to type B and A work sectors.
The sole access to type A work sectors must be through a change room with a shower and a decontamination facility.

7. REFERENCES

[1] **Loi sur la Radiation protection (LRaP) 814.50**, 22 March 1991 / use of the English translation provided by the Federal Authorities of the Swiss Confederation : Radiological Protection Act (RPA)

[2] **Ordonnance sur la Radiation protection (ORaP) 814.501**, 22 June 1994 / use of the English translation provided by the Federal Authorities of the Swiss Confederation : Radiological Protection Ordinance (RPO)

[3] **Directive pour les installations nucléaires suisses, IFSN-G15/f, Objectifs de radiation protection applicables aux installations nucléaires**, Inspection Fédérale de la Sécurité Nucléaire, November 2010

[4] **Richtlinie für den überwachten Bereich der Kernanlagen und des Paul Scherrer Institutes HSK-R-07**, June 1995

[5] **Organisation de la radiation protection à la centrale nucléaire de Beznau en Suisse, July 2006. CEPN report no. 06/23,** P. Croüail, P. Domisse, F. Drouet, E. Hauser

[6] **Ordonnance sur les accélérateurs (médical) (OrAc) 814.501.513**, 15 December 2004

[7] **Ordonnance sur l'utilisation de sources radioactives scellées en médecine (OSRM) 814.501.512**, 15 November 2001

[8] **Ordonnance sur les installations radiologiques à usage médical (Ordonnance sur les rayons X) 814.542.1**, 20 January 1998

[9] **Directive R-06-03 concernant la surveillance dosimétrique dans les hôpitaux, Office Fédéral de Santé Publique**, April 2010

[10] **Ordonnance concernant la radiation protection applicable aux installations non médicales de production de radiations ionisantes (Ordonnance sur la radiation protection dans l'utilisation d'installations) 814.501.51**, 31 January 2001

[11] **Ordonnance sur l'utilisation des sources radioactives non scellées 814.554**, 21 November 1997