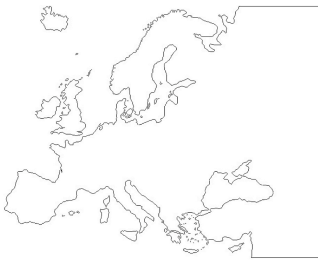

European
ALARA
Network

Survey on radon exposure management
September 2009 - January 2010

Questions sent to the members of the Network:

1. *Is there a specific radon policy in your country?*
2. *If so, when was it implemented?*
3. *Have action levels (ICRP 60) or reference levels (ICRP 103) been fixed? For workplaces? For domestic dwellings?*
4. *How far is this policy implemented?*
5. *We would also be interested in documentations related to this policy (even if it is not in English).*

Short summary of the answers

In most countries, regulations are currently based on EC Directives 96/29/EURATOM for workplaces and EC recommendation 90/143/EURATOM for dwellings.

For workplaces, action levels are defined either in terms of radon concentration (Bq/m^3) or in radon concentration-hours ($Bq.h/m^3$), which take into account the duration of exposure. The range of levels varies respectively between 400 and 3000 Bq/m^3 (most of the time 400 Bq/m^3) and between 800 and 2000 $kBq.h/m^3$.

For dwellings, actions levels are defined only in terms of radon concentration (Bq/m^3): and range between 100 and 1000 Bq/m^3 (most values are 200 or 400 Bq/m^3).

In September 2009, the WHO published the WHO Handbook on Indoor Radon, which proposes new levels for managing radon in dwellings. The WHO now recommends a reference level of 100 Bq/m^3 to minimize health hazards due to radon. If compliance with this level cannot be achieved, the reference level should not exceed 300 Bq/m^3, which represents approximately an effective dose of 10 mSv/year.

Many countries have initiated a process to revise the regulation or recommendations, in particular after the publication of the WHO Handbook in September 2009. It is the case in Belgium, Denmark, Finland, Switzerland and the UK.

Other countries, e.g. Italy, which had no regulation on radon in dwellings, after the publication of the WHO Handbook decided to start a process to set up a regulation based on the WHO recommendations.

The Table 1 summarizes the national action levels for workplaces and dwellings. More details on the national policy and levels of implementation are given in the following paragraphs.

Table 1. Nation action levels for workplaces and dwellings

Country	Regulation	Action levels for workplaces	Action levels for dwellings
Austria	Recommendation Austrian RP Commission (1992) NORM Ordinance (2008)	Action level: 400 Bq/m³ (maximal 20 mSv/a including all NORM expositions)	Existing: 400 Bq/m³ New: 200 Bq/m³
Armenia	*Under development*		
Belgium	Federal RP regulation (2001) FANC radon action plan (2005)	3 mSv/y or 800 kBq.h/m³ (compulsory)	Existing: 400 Bq/m³ New: 200 Bq/m³
Croatia	*No formal official policy defined yet*		
Czech Republic	Governmental Decision (1999) Decree of the SONS (2002)	Action level: 1000 Bq/m³	Existing buildings: 400 Bq/m³ New buildings: 200 Bq/m³
Denmark	*For dwellings:* Building Code	Action level: 400 Bq/m³	New buildings: 100 Bq/m³ Existing buildings: 100 Bq/m³ for simple remedial measures 200 Bq/m³ for more comprehensive and costly measures
Finland	Decision of Min. of Social Affairs & Health 944/1992 Radiation Act 592/1991	Action level: 400 Bq/m³	Existing buildings: 400 Bq/m³ New buildings: 200 Bq/m³
France	*Public buildings:* Code of Public health (2007) Ministerial order 07/2004 National radon action plan (2005-2008) *Workplace:* Ministerial order 08/ 2008 *Dwellings:* Law (07/ 2009)	400 Bq/m³ 1000 Bq/m³	Existing public buildings: 400 Bq/m³ 1000 Bq/m³ New buildings: 200 Bq/m³ (recommended value)

currently under revision or recently revised - more information in the text

Table 1. Nation action levels for workplaces and radon

Germany	*Dwellings:* only recommendation Workplace: legislation (RP ordinance 2001)	2.10^6 Bq.h/m^3 (20 mSv/y ⇔ 6.10^6 Bq.h/m^3)	Voluntary action level: 100 Bq/m^3 (annual mean value)
Greece	RP Regulations 2001 Recommendation 90/143/EURATOM	400 Bq/m^3	Existing: 400 Bq/m^3 New: 200 Bq/m^3
Ireland	RP Act, 1991 - (IR) Order 2000 (for workplaces)	400 Bq/m^3 (since 2000)	Homes (since 1990): 200 Bq/m^3 Schools (since 1998): 200 Bq/m^3
Italy	Decree May 2000	Workplaces: 500 Bq/m^3 (annual average) NORM industries, spas and mines: 1 mSv/y of total effective dose (see the text for details)	*Decided to be set-up on the basis of the WHO recommendations*
Lithuania	HN 85:2003	Existing: 400 Bq/m^3 [a] or 800 Bq/m^3 [b] New: 200 Bq/m^3 [a] or 400 Bq/m^3 [b]	Existing: 400 Bq/m^3 New: 200 Bq/m^3
Slovenia	Ionizing Prot. & Nuc. Safety Act	1000 Bq/m^3 3200 Bq/m^3 (cat. A workers)	400 Bq/m^3 Recommended value: 200 Bq/m^3
Spain	Royal Decree 783/2001 Specific criteria defined in 2007	Action level for remedial actions: 400 Bq/m^3 New buildings: 200 Bq/m^3	Action level for remedial actions: 400 Bq/m^3 New dwellings: 200 Bq/m^3
Sweden	Radon program since 1980	400 Bq/m^3	200 Bq/m^3 (existing and new buildings)
Switzerland	RP ordinance June 22, 1994	3 000 Bq/m^3	Compulsory remediation: 1 000 Bq/m^3 New construction and remediation programmes: 400 Bq/m^3
UK	Initial advice in 1987, updated in 1990	400 Bq/m^3 (annual average)	200 Bq/m^3 (annual average)

currently under revision or recently revised - more information in the text

a. If more than 80% of working time is spent in the building

b. If less than 80% of the working time is spent in the building

Austria

Radon policy

In 1992 the Austrian Radiation Protection Commission published recommended limits for annual average indoor air radon activity concentrations based on recommendations of the ICRP and the European Commission: 400 Bq/m³ in existing buildings as intervention level for existing buildings, and 200 Bq/m² as design level for new buildings. From 1992 to 2001 the spatial distribution of the radon risk in Austria was investigated within the frame of the Austrian National Radon Survey (ÖNRAP). In the course of this project about 40000 indoor air radon measurements in about 16000 rooms in Austrian buildings were carried out. The project work was jointly done by several institutes of Austrian universities, research laboratories, operational supported by departments of Federal Country Offices and financially supported by the Austrian Ministries of Health and Environment. Coordinator of the ÖNRAP project was Harry Friedmann, University of Vienna.

The measured indoor air radon concentrations have been converted to radon potential values, which represent standardized building construction and user situation. Therefore, these radon-potential values represent the local radon risk. The radon-potential values measured and calculated during the ÖNRAP project are log-normal distributed with a mean value of about 99 Bq/m³, and a median value of about 61 Bq/m³.

After subdivision of the radon-potential into three classes – <200 Bq/m³, 200–400 Bq/m³, > 400 Bq/m³ – the spatial distribution has been averaged for each community. The radon potential classes of the Austrian communities are displayed on the Austrian radon-potential map [1].

Implementation

The radon studies provide the basis for decision on precaution measures (new buildings) and evaluation/mitigation measures (existing buildings) for indoor radon. In the Federal Country Upper Austria, the grant directive for radon measurement, precaution and mitigation is related to the radon potential map.

From 1996 to 2004 scientifically supported work was done – mainly in Upper and Lower Austria – to test radon mitigation and precaution measures in practice. It was done both in private houses and in public buildings e.g. kindergartens, schools [2, 3]. From 2004 to 2006, the radon exposure in waterworks has been investigated.

All scientific and practical experience on radon gained in Austria between 1992 and 2009 were incorporated into three Austrian radon standards:

- ÖNORM S5280–1: Radon, measuring procedures and their applications [4]
- ÖNORM S5280–2: Radon, part 2: Constructive precaution measures for buildings [5]
- ÖNORM S5280–3: Radon, part 3: Mitigation measures for buildings [6]
-

The three standards represent the state of the art and best available technology for radon measurement, precaution and mitigation for buildings in Austria at present.

In 2008 the Austrian NORM Ordinance [7] was presented by the Federal Ministry of Agriculture and Forest Economy, Environment and Water Management (BMLFUW). In this legislative document the action levels and limits for radon at workplaces are constituted: Action level at workplaces: 400 Bq/m³, dose limit for all NORM radiation sources at the workplaces including radon: 20 mSv/a.

References

[1] Friedmann, H.: Final Results of the Austrian Radon Project. Health Physics 89(4): 2005, pp. 339–348
[2] Maringer, F. J.; Lueginger, S.; Akis, M. C.; Kaineder, H.; Kindl, P.; Kralik, C.; Lettner, H.; Nadschläger, E.; Ringer, W.; Rolle, R.; Schönhofer, F.; Sperker, S.; Stadtmann, H.; Steger, F.; Steinhäusler, F.; Tschurlovits, M.; Winkler, R.: Results and conclusions of the Austrian radon mitigation project 'SARAH'. Proc Radon in the living environment. Ed. Simonoupulos, S. E., Scivyer, Ch. Athens, 19–23. April 1999. Nat. Techn. Univ. Athens, Greece, 2000, pp. 1205–1218
[3] Maringer, F. J.; Kaineder, H.; Nadschläger, E.; Sperker, S.; Karg, V.; Ringer, W.: Radon in oberösterreichischen Kindergärten: Erhebung, Sanierung und Vorsorge. (Radon in Upper Austrian kindergartens: investigation, mitigation and precaution.) Publikationsreihe Fortschritte im Strahlenschutz. Strahlenschutz für Mensch und Gesellschaft im Europa von Morgen. TÜV-Verlag GmbH, München. 2001, pp. 162–165 (in German)
[4] ÖNORM S 5250-1: Radon, Messverfahren und deren Anwendungsbereiche. (Radon, measuring procedures and their applications.). 2nd ed. Österreichisches Normungsinstitut, Wien, 2008 (in German)
[5] ÖNORM S 5280-2: Radon Teil 2: Technische Vorsorgemaßnahmen bei Gebäuden. (Radon part 2: Constructive precaution measures for buildings.) Österreichisches Normungsinstitut, Wien, 2003 (in German)
[6] ÖNORM S 5280-3: Radon Teil 3: Sanierungsmaßnahmen an Gebäuden. (Radon part 3: Mitigation measures for buildings.) Österreichisches Normungsinstitut, Wien, 2005 (in German)
[7] Natürliche Strahlenquellen-Verordung. BGBl. II 2/2008. Bundesminister für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft.

Armenia

Armenian authorities have not established a formal policy on radon yet. Up to now, they have just started to investigate the territory of Armenia in order to define radon-prone areas. This action is stated in the national plan for public health. Measurements will be made in different parts of Armenia and the results will be assessed. Based on this assessment, specific action levels will be defined.

Belgium

Radon policy

The Federal RP Regulation (RGPRI-ARBIS) has been in application since 2001. The FANC radon action plan has been in operation since 2005. Previous radon activities

(measurement campaigns, mapping, public awareness, brochures, etc.) were carried out by the Health Ministry in collaboration with different universities and research centres since the early 90s, based on the ICRP, EU and WHO publications.

Implementation

Based on about 11 000 indoor radon measurements and 4 000 soil-gas measurements, mapping of the radon-prone has been accomplished. Public awareness activities, measurement campaigns and building prevention actions (training of building professionals, spreading of information, etc.) are annually defined in the frame of the radon action plan and focussed on specific regions based on radon maps.

References

FANC radon website:
http://fanc.fgov.be/fr/page/bienvenue-sur-le-site-radon-de-l-afcn/646.aspx
Info on radon mapping:
http://radonmapping.jrc.ec.europa.eu/fileadmin/Documents/WorkingDocuments/National_Summary_Reports/BELGIUM_Rn.pdf

Czech Republic

Policy

The specific radon policy was implemented in 1999 and was based on a Governmental Decision. Requirement for measuring radon was already mentioned in Atomic Act No.18/1997 Coll. The Governmental Decision was amended several times and the current version (No.594 of 2009) prolongs the radon programme till 2009. The current action levels are given by the Decree of the State Office for Nuclear Safety No.307/2002 Coll.:

- Workplaces: 1000 Bq/m^3,
- Dwellings:
  - 400 Bq/m^3 for existing buildings,
  - 200 Bq/m^3 for new buildings.

Implementation of the radon programme

The radon map of the Czech Republic has been completed and is available on the Internet. 160,000 dwellings were measured as part of the investigation programme. 20 research projects concerning radon in dwellings were performed and outputs were used for example for drafting new technical standards. Finally state subventions for remedial actions were granted.

References

http://www.suro.cz/en/prirodnioz/rnprogram
http://www.sujb.cz/?c_id=542

Denmark

Recommended levels for dwellings

At the end of 2009, the Danish Building Authority lowered the levels for radon defined in the Building Code:

- For new buildings: 100 Bq/m^3,
- For existing buildings:
  - 100 Bq/m^3 (instead of 200 Bq/m^3) for simple remedial measures,
  - 200 Bq/m^3 (instead of 400 Bq/m^3) for more comprehensive and costly measures.

Finland

Domestic buildings:

Reference levels from decision of Ministry for Social Affairs and Health 944/1992
Building code D2, Indoor climate and ventilation in buildings, Regulations and Guidelines 2003, Ministry of Environment: new houses must be designed and constructed so that indoor air is free of harmful concentrations of gases, particles or microbes or odours, which decrease the indoor comfort.

Building code D3, Substructures, Regulations and Guidelines 2004, Ministry of Environment: in the design and construction work, radon risks at the concentration site shall be taken into account. A radon-technical design is required in all building as a main rule in the whole country.

STUK is currently working on the revision of the reference level for dwellings: the objective is to lower the level at 200 Bq/m^3 for all dwellings.

Workplace and public buildings

Section 45 of the Radiation Act (592/1991): the employer shall measure radon concentration in working premises if there is reasonable cause to suspect that the action level of 400 Bq/m^3 (Section 27 of the Radiation Decree 1512/1991) might be exceeded. The action level is 400 Bq/m^3 in workplaces where people are working regularly. If the work is not regular, the annual mean of radon concentration may be higher than 400 Bq/m^3 (ST 12.1 Radiation safety in practices causing exposure to natural radiation, 6 April 2000) up to 6 000 Bq/m^3 (see Table 2) At schools, nurseries and corresponding public buildings, radon concentration, shall be less than 400 Bq/m^3 even if the occupancy is not regular. If radon concentration exceeds the action level, the responsible party shall take necessary measures to reduce exposure.

STUK carries out periodic inspections in underground mines and underground quarrying sites.

Table 2. Action levels for radon at workplaces in Finland

Annual working time	Action level for radon concentration (Bq/m³)
Regular work (1 600 h/y)	400
Max. 600 h/y	1 000
Max. 300 h/y	2 000
Max. 100 h/y	6 000

References

Radiation act 592/1991: http://www.edilex.fi/stuklex/en/lainsaadanto/19910592
Radiation decree 1512/1991:
http://www.edilex.fi/stuklex/en/lainsaadanto/19911512
ST 12.1 Radiation safety in practices causing exposure to natural radiation, 6 April 2000: http://www.edilex.fi/stuklex/en/lainsaadanto/saannosto/ST12-1

France

Public buildings
Ministerial order of 22/07/04 related to the modalities of management of radon risk in public buildings

Since 2004, in 31 "départements" identified as being likely to be affected by radon, radon measurements are mandatory in hospitals, schools, prisons and thermal establishments. Two action levels are defined:
- 1000 Bq/m³: radon diagnosis and immediate implementation of remediation actions,
- 400 Bq/m³: implementation of simple corrective actions within a 2-year time,

For other departments, the same rules are applied if previous radon measurements showed radon concentration above the action levels.

Workplaces
Ministerial orders of 07/08/08 and 26/09/08 related to the management of radon risk in workplaces. The following activities are concerned if they are performed at least one hour a day in underground places:
- Maintenance and surveillance of roads and car parks,
- Maintenance and surveillance of vehicles,
- Supply of goods or equipments,
- Restaurant and hotel activities,
- Maintenance and organization of touristic visits,
- Civil engineering and equipment,
- Workers in public buildings listed above.

When radon measurements are above 400 Bq/m³, the employer must implement necessary technical actions: check of aeration, improvement or re-establishment of natural ventilation, diagnosis of buildings, investigations allowing to identify the

source of radon, remedial actions or work organisation. If radon measurements are still above 1000 Bq/m^3, the employer must implement individual monitoring, ambient monitoring and medical surveillance.

Dwellings
The risk linked to radon in dwellings is considered as one of the priorities of the "Health and Environment National Programme". In July 2009, a new regulatory framework has been implemented by law for managing radon-related risks in dwellings. Reference levels for dwellings will be implemented by a decree.

http://www.asn.fr/index.php/Les-actions-de-l-ASN/La-reglementation/Cadre-legislatif

http://www.asn.fr/index.php/Haut-de-page/Professionnels/L-accreditation-et-l-agrement-d-organismes/Radon

http://www.asn.fr/index.php/S-informer/Actualites/2006/plan-d-actions-radon

http://www.sante-sports.gouv.fr/publications-documentation/publications-documentation-sante/rapports/deuxieme-plan-national-sante-environnement-pnse2-2009-2013.html

Germany

References

Regulation for Workplace: § 93-96 of the Ordinance on the Protection against Damage and Injuries caused by Ionizing Radiation of 20 July 2001, last amendment of 13 December 2007
http://www.bfs.de/de/bfs/recht/rsh/volltext/A1_Englisch/A1_12_07.pdf
http://www.bfs.de/de/ion/beruf_schutz/arbeitsfelder.html
Chapter 2.2 of http://www.bfs.de/de/bfs/druck/uus/parlamentsbericht07.pdf

For dwellings, only recommendations: information sheets, publications and special prevention campaigns of the Federal Office for Radiation Protection and the Ministry of Environment, Natural Conservation and Reactor Safety.
http://www.bfs.de/en/ion/radon/radon_in_haeusern.html
http://www.bfs.de/en/ion/radon/massnahmen_radon.html

Greece

Workplaces - Greek Radiation Protection Regulation

- Workplaces at which the average annual total radon concentration (annual working time of 2 000 hours) is less than 400 Bq/m^3 shall be exempted from further control and radiation protection measures,
- In workplaces at which the average annual total radon concentration is greater than 400 Bq/m^3 and less than 1 000 Bq/m^3, the possibility of reducing the above

concentration using appropriate technologies shall be investigated. These workplace shall be defined as supervised areas and the radiation protection measures taken must be approved by GAEC,
- In workplaces at which the average annual total radon concentration is greater than 1 000 Bq/m^3 and less than 3 000 Bq/m^3 shall be defined as controlled areas and the practices in question must be authorised by GAEC,
- The average annual total concentration of radon at the workplace may not exceed 3 000 Bq/m^3 for an annual working time of 2 000 Bq/m^3.

Implementation

A lot of measurements have been performed. However, the project of constructing the radon map is not completed yet. Brochures and other informative material relevant to radon issues have been produced and widely distributed.

Ireland

Homes

The Reference Level for radon in homes in Ireland is 200 Bq/m^3. This came into effect in 1990.

Measurement protocols published by the Radiological Protection Institute of Ireland (RPII) specify that the measurement in homes is to be made using passive CR-39 detectors exposed in a bedroom and living room for at least 3 months. The results seasonally corrected to estimate the annual average radon concentrations and it is this figure that is compared to the Reference Level[1].

Schools

The Reference Level in schools is 200 Bq/m^3. This level was set in 1998.

Measurement using passive CR-39 detectors exposed in each ground-floor or basement area for at least 3 months (normally school year is chosen - 9 months)[2]. If any one area in the school is above the Reference Level then remediation is likely to be needed.

Workplaces

The Reference Level in workplaces is 400 Bq/m^3. This level is specified in legislation Radiological Protection Act, 1991, (Ionising Radiation) Order 2000, S.I. No. 125 of 2000.

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1 RPII Measurement protocol for determination of the annual average radon gas concentration in domestic dwellings, August 2008, www.rpii.ie

2 *Synnott et al*, Radon in Irish Primary and post Primary Schools - the results of the national survey (2004). www.rpii.ie.
Synnott et al., Radon in Irish Schools: the results of a national survey, J. Radiol. Prot. 26 (2006) p. 85-96, and The effectiveness of radon remediation in Irish schools, Health Physics Jan 2007, Vol. 92, No. 1, p. 50 – 57.

Guidance published by the RPII specifies that in each occupied ground-floor or basement area must be measured. The measurement period is at least 3 months[3,4]. If any one area in the workplace premises is above the Reference Level then remediation is likely to be needed.

New buildings

Building Regulations requiring radon preventive measures in new buildings were introduced in 1998[5].

Implementation

The national radon survey was carried out during the 1990's and published in 2002[6]. The radon map of Ireland showing those parts of the country particularly at risk from radon was published in 2000[7].

Radon policy applies to the whole country however radon awareness and regulatory efforts focus on the areas most at risk from radon.

National radon forum

Each year the RPII hosts a national radon forum. The purpose of the Forum is to provide an opportunity for those with a role to play in reducing the risk from radon in Ireland to meet and discuss radon activities and concerns. This includes measurement companies, remediation companies, scientists, government representatives, local authorities, representatives of national agencies with responsibility for building standards, health and safety experts and the public.

Evolution of the regulation

In 2005, the RPII reviewed the applicability of the Reference Level in Ireland. At that time, the review recommended continuing with the present Reference Level of 200 Bq/m^3 as it represented a level of risk to the population as a whole comparable to other everyday risks. The present Reference Level of 200 Bq/m^3 is within the range recommended by the WHO. The average indoor radon concentration in Ireland is 89 Bq/m^3, which is among the highest in Europe. Reducing the Reference Level to below 200 Bq/m^3 for example to 100 Bq/m^3 may not be achievable as it would require considerable resources.

Having said this, the RPII would recommend a revision national radon policy which would take account of all the elements of a national radon strategy of which the Reference Level is one. For example, as well as considering the Reference Level, any revision of the strategy should also address other key measures such as the

3 Guidance notes to assist with the planning of radon surveys in workplaces, www.rpii.ie.
4 Guidance notes on the actions an employer may take if high radon concentrations are found in a workplace. August 2008, www.rpii.ie
5 Technical Guidance Document C – site preparation and resistance to moisture. Department of the Environment, Heritage & Local Government 2008, www.environ.ie.
6 *Fennell et al*, Radon in Dwellings, The Irish National Radon Survey (2002) RPII-02/1, www.rpii.ie.
7 The radon map of Ireland can be viewed on the RPII's website, www.rpii.ie.

effectiveness building control measures, the training of building professionals, the designation of High Radon Areas, public awareness efforts etc.

Documentation

- *Colgan et al*, Radiation Doses Received by the Irish Population, (2008) RPII 08/01 http://www.rpii.ie/CMSPages/GetFile.aspx?nodeguid=003644df-6cf8-428f-9752-ba24af66bf09&PublicationID=657

- Health Risks due to Exposure to Radon in Homes in Ireland. Joint Statement by the Radiological Protection Institute of Ireland and National Cancer Registry of Ireland September 2005 http://www.rpii.ie/CMSPages/GetFile.aspx?nodeguid=ae8ae88a-a7ce-4edb-86c2-8d1125c6b63b&PublicationID=838

- *Colgan P A, Madden J S, Synnott H, Fennell S, Pollard D and Fenton D*, 2004, Current status of programmes to measure and reduce radon exposure in Irish workplaces *J. Radiol. Prot.* 24

- Technical Guidance Document C – site preparation and resistance to moisture. Department of the Environment, Heritage & Local Government 2008 http://www.environ.ie/en/Publications/DevelopmentandHousing/BuildingStandards/FileDownLoad,1642,en.pdf

- Office of the Attorney General, Dissemination of information on radon. Reference SR4/86 B2583. July 2000.

- Full details of the RPII's radon awareness efforts including all press releases on radon and information on the National Radon Forum is on the RPII website. Radiological Protection Institute of Ireland | | Media | Press releases. Radiological Protection Institute of Ireland | Your Environment | Radon and your environment | National Radon Forum.

Italy

Radon policy

The 96/29 Euratom Directive, Title VII included, was transposed in the Italian Radiation Protection Act issued in 2000 (Decreto legislativo 26 maggio 2000, n.241. Supplemento ordinario alla *Gazzetta Ufficiale della Repubblica Italiana*, August 31st, 2000).

Workplaces

Action level for workplaces (underground workplaces and not underground workplaces located in selected areas - *radon-prone areas* - or in selected buildings whose characteristics could produce high indoor radon concentration - *radon-prone buildings)*: action level 500 Bq/m^3 for an occupancy time of 2000 h/y.

If the radon activity concentration in air is lower than the Action Level, but higher than 80% of its value, the annual measurement should be repeated. If it is higher than the Action Level, remedial action to reduce the concentration significantly below it are required, together with a new annual measurement to verify their effectiveness. Remedial actions should not be adopted if the effective dose is lower than 3 $mSv.y^{-1}$ for all workers (low occupancy time). However, for nurseries and schools the action level is 500 Bq/m^3 regardless occupancy time.

If all the remedial action undertaken is not effective enough to reduce radon activity concentration to significantly below the Action Level, the workplace should be subjected to the usual radiation protection control system for practices, where applicable.

NORM industries.

Action Levels for workers and the population for work activities with NORM are stated in 1 $mSv.y^{-1}$ and 0.3 $mSv.y^{-1}$ of total effective dose, respectively. The radon activity concentration in indoor air due to the workplace characteristics (that is from the underlying soil or building material) is excluded from the dose levels, because it is independent of the work activity involved and is regulated by the Action Level for radon at work. Radon due to the activities is included.

If doses to workers turn out to be lower than the Action Level but higher than 80% of its value, measurements should be repeated every year.

If Action Levels are exceeded, the employer must adopt corrective measures within three years.

If, notwithstanding the corrective measures, doses continue to exceed the Action Level, the radiation protection control system for practices, for both workers and the population, should be applied.

Thermal spas and mines

Spas and mines are considered a particular case, being radon concentration related to the work activity. The Action Level is in terms of effective dose (1 $mSv.y^{-1}$), which includes the effective dose due to radon, gamma etc.

Action levels for existing buildings

At present no action levels have been set for radon in existing dwellings in Italy. However, upon the publication of the WHO Handbook on Indoor Radon on September 21st 2009, it was decided that a proposal of regulation for radon in dwellings (including action/reference levels for existing buildings) will be drafted, in the framework of the Italian National Action Plan on Radon, by the Ministry of Health in collaboration with the 21 Italian Regions, taking into account the latest WHO recommendations.

Building codes for new buildings

A recommendation has been given by the Scientific Committee of the Italian National Action Plan on Radon regarding the implementation of simple preventive measures against radon for all the new buildings for all the Italian territory, with no regards to the radon levels in the area. This recommendation should be accepted by the 21 Italian regions and inserted in the building codes of each Municipality. This process is expected to take several months.

Reference

Risica S., Bochicchio F., Nuccetelli C., The implementation in national legislation of Title VII of the Council Directive 96/29/Euratom: some general remarks and the case of Italy, In: *Proceedings of the 7th International Symposium on The Natural Radiation Environment (NRE-VII), Rhodes, Greece, 20-24 May 2002.*

Slovenia

Radon policy

General provisions in Ionizing Protection and Nuclear Safety Act (articles 45 & 46). Radon policy was formally implemented in February 2006, when the government adopted the "Programme on systematic monitoring of working and residential environment and raising awareness about measures to reduce public exposure due to the presence of natural radiation sources". Nevertheless, since early 90s, radon campaigns have been performed by the Ministry of Health in cooperation with the Jožef Stefan Institute from Ljubljana.

Actions levels for workplaces and dwelling are based on ICRP 60 recommendations and IAEA 115 Basic Safety Standards. Action levels of 400 Bq/m^3 (dwellings), 1000 Bq/m^3 (normal and category B workplaces) and 3200 Bq/m^3 (category A workplaces) have been derived using IAEA BSS 115 and 96/29/Euratom dose conversion factors. However, ALARA principle shall be always considered. Rules on the ventilation and air-conditioning of buildings (issued in Official Gazette No. 42/2002) in dwelling places limit annual average radon concentration below 400 Bq/m^3 and recommend values below 200 Bq/m^3.

Special case

Special case is a group of workers (guides) in touristic karstic caves, where dose conversion factors are larger because of higher concentration of "unattached" decay products in air. For this case, Slovenian radon experts proposed to use ICRP 32 recommendations. However, ICRP 32 is more than 25 years old, new ICRP recommendation dealing with this specific issue would be useful.

Implementation

Inspections and preventive measures are performed to follow the implementation of the regulation. However, the policy for domestic places is implemented in limited

extent due to different reasons (mainly prevail economical, social, organizational and human factors).

References

Ionizing Protection and Nuclear Safety Act:
http://www.ursjv.gov.si/fileadmin/ujv.gov.si/pageuploads/si/Zakonodaja/SlovenskiPredpisi/zvisjv-ang.pdf
Programme on systematic monitoring of working and residential environment and raising awareness about measures to reduce public exposure due to the presence of natural radiation sources: http://zakonodaja.gov.si/rpsi/r07/predpis_DRUG2207.html (in Slovenian).

Spain

Regulation

Royal Decree 783/2001, on Health Protection Against Ionizing Radiation (RPSRI) is the Spanish legislative framework for the protection against ionizing radiation. Protection against natural radiation sources is defined in Title VII and, following the Directive structure, is composed of three articles: 62 "Application"; 63 "Terrestrial sources of natural radiation; and 64 "Aircrew members". The CSN approved in 2007 specific criteria for implementing the protection to natural radiation sources in the country.

Development of the radon policy

In 1989, the CSN (Nuclear Safety Council) launched a program with the main goal of assessing the indoor ^{222}Rn exposure of Spanish population in dwellings and identifying radon-prone areas in the countries. Between 1989 and 2002, many projects were launched, for example studies in two specific zones with high-radon levels or radon measurements in workplaces such as caves and health spas. In 2002, an action plan was launched by the CSN for the development and application of Title VII on "*Exposure to natural radiation sources*" in RPSRI, including radon in dwellings.

In 2009, measurements have been made in about 10 000 houses and, in the next two years, it is foreseen to obtain radon level values in 8 000 additional houses throughout the country.

Information of the public

Additionally to the ^{222}Rn measurements in dwellings and workplaces, the CSN, according to the recommendation 90/143/Euratom, provides information to the public on natural radiation by means of participation in scientific fairs, edition of specific publications on natural sources of exposure, and an information centre, partly devoted to the different sources of natural radiation exposures. The information centre was visited by 6 740 persons in 2008. Finally, in 2002, a CD-Rom entitled "*Radon a natural radioactive gas in your home*" was published by CSN in collaboration with the Cantabria University.

Table 3. Radiological criteria to set up corrective actions and radiation protection measures.

Dwellings	Workplaces	
Action level for remedial 400 Bq/m^3	Action level for remedial actions 400 Bq/m^3	
If simple measures are possible 200 Bq/m^3	< 400	No protection is needed.
	400-1000	Low level of protection
	> 1000	High level of protection
Design level for new dwellings 200 Bq/m^3	Design level for new buildings. 200 Bq/m^3	

Implementation of the regulation

Up to now, CSN's work has been especially focused on the development of radon prevention and mitigation standards and the study of the effectiveness of different radon mitigation options. The Spanish Technical Building Code (CTE) is the normative framework that establishes the safety and habitability requirements of buildings, set out in the Building Act (LOE), enacted in 2000. During the drafting of the CTE and with the aim of introducing the aspect of radon protection in this document a working group was formed between the Eduardo Torroja Construction Sciences Institute and the Nuclear Safety Council staffs.

A series of radon protection techniques were suggested and each preventive solution was made up: a plan showing the method proposed, the potential use and the way of using it and additional points to be considered; membrane lapping and sealing, building services penetrations, subfloor ventilation, radon sump details, construction joints, concrete specifications. The CSN is now preparing a specific document about this topic to be edited in 2010.

Sweden

Action levels in the regulation

Since 1981 Sweden has defined different action levels for radon. In 2009 action levels are the following:

- Dwellings and common places where the general public is admitted (i.e. schools, pre-schools, etc.):
  - For existing dwellings: 200 Bq/m^3 - this level has been change several times since 1980; it was lowered from 400 Bq/m^3 to 200 Bq/m^3 in 2004.
  - For new building: 200 Bq/m^3.

- Ordinary workplaces: 400 Bq/m^3,

- Mining and similar excavating work: 1500 Bq/m^3

- Radon in drinking water:
  - Public water: 100 Bq/L,

- Private wells: 1000 Bq/L.

There are two targets: the radon concentration should be lower than 200 Bq/m^3 in schools and pre-schools by the year 2010, and in homes by 2020.

Measurements

Since the early 1980s measurements have been carried out in an estimated 500,000 homes, corresponding to more than 10% of the housing stock and remediation has been carried out in nearly 50,000 homes with concentrations exceeding the action. The targets adopted by the Government and the reduced action level mean that 400,000 homes, including 300,000 single-family dwellings, will need to be identified and remediation carried out over a 20-year period.

Implementation

The program is implemented via the municipalities. For home owners the action level for existing dwellings is regarded as a strong recommendation. For owners of apartment buildings that rent out flats, the municipalities can demand measurements and mitigation if the action level is exceeded. For single-family homes with radon levels exceeding 200 Bq/m^3, owners can receive a grant, which cover half the cost of remediation actions, with a maximum of about 2000 € (15000 Swedish Krona). This grant is attributed only if the radon source is identified and if radon concentration is measured after remediation.

Perspectives for the evolution of the regulation for dwellings

After the publication of the WHO Handbook on radon in September 2009, the central authorities responsible for radon issues in Sweden discussed the new recommended reference levels. The conclusion was that it is hardly possible to reduce the reference level for existing dwellings at 100 Bq/m^3. In fact, there is in Sweden a large number of dwellings with radon levels between 100 and 200 Bq/m^3, and for many of them, it would not be possible to reduce the level under 100 Bq/m^3 with reasonable remediation efforts. However, investigations have been launched to reduce the reference level for new dwellings to 100 Bq/m^3.

Reference

L. Mjönes, A-L. Söderman (SSM), Radon Perception in Sweden

Switzerland

The SFOPH has been conducted since 1994 a national radon program according to the Swiss legislation on radiological protection. This legislation addresses limits and guide values, measurements laboratories and programs, building regulations and protective/ remedial actions and risk management through the radon technical and information Center (inclusive national radon database and education/training of consultants). More detailed information can be found on the SFOPH radon website: www.ch-radon.ch.

In 2010, the SFOPH will propose a National Action Plan for radon to the Federal Council taking into account the new WHO recommendation. The lowering of the limit to 300 Bq/m^3 for dwelling and the question of remediation for buildings in which levels between 300 and 1000 Bq/m^3 have been measured, will be the subject of in-depth discussions during the next revision of the Ordinance on Radiological Protection. The overall process of the legislation revision and the action plan implementation will be done in dialogue with the various concerned stakeholders.

UK

Radon Affected Areas are defined as areas where more than 1% of the homes are estimated to be above the Action level. If the probability is more than 3%, basic preventative measures are required for new houses. If the probability is more than 10%, further preventative measures are required for new houses.
The action levels for homes are currently being revised. Public consultation has been launched by HPA - "HPA advice on the limitation of human exposure to radon"
http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1243928249585

Proposals:

- Keep the actual recommendations:
  - Action level: 200 Bq/m^3
  - Radon Affected Areas: more than 1% of the homes are estimated to be above the Action level.
- Change the Action level and criteria for radon Affected Areas:
  - Action level: 100 Bq/m^3
  - Radon Affected Areas: more than 5% of the homes are estimated to be above the Action levels.
- Change the Action level and criteria for radon Affected Areas:
  - Action level: 100 Bq/m^3
  - Radon Affected Areas: Low (<5%), Medium (between 5 and 30%) and High (>30%) radon risk.
- Proposal for applying the same Action level for non-domestic building with prolonged public occupancy.

References

Action level in workplaces - The Ionising Radiations Regulations 1999, No. 3232
http://www.opsi.gov.uk/si/si1999/19993232.htm
http://www.opsi.gov.uk/si/si1999/19993232.htm
Advice for homes: "Limitation of human exposure to radon in homes" and "Human exposure to radon in home" - Documents of the NRPB volume 1, No. 1, 1990

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