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ScienceDirect

Energy Procedia 140 (2017) 13–22

Energy Procedia

www.elsevier.com/locate/procedia

AiCARR 50th International Congress; Beyond NZEB Buildings, 10-11 May 2017, Matera, Italy

Radiation protection considerations on radon and building materials radioactivity in Near Zero Energy Buildings

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Abstract

Recent updates of the E.U. Basic Safety Standards, stated in the Council Directive 2013/59/EURATOM, are focusing on risks related to radon gas concentration inside dwellings and working places, as well as radioactivity of building materials. In particular, the new E.U. Basic Safety Standards are based on last recommendations from the International Commission on Radiological Protection (ICRP), and from the World Health Organization (WHO), which consider that radon issues, and external irradiation from building material, as topic aspects to population's health. Further, ICRP Publication 126, by using bio-kinetics models for estimating the effects of radon intakes, has drastically reduced the reference level for radon concentration in dwellings and working places.

Radon issues have recently gained particular attention due to current orientations in constructing buildings with energy consumptions lower and lower. Radon gas emerges from the ground, penetrates building's basements, and accumulates itself into the indoor air, being breathed by people.

Taking care of windows' airtightness allows the radon concentration to build up, in some cases beyond reference levels, together with other chemical pollutants, i.e. combustion residues and solvents.

On considering that Council Directive 2013/59 EURATOM has to be transposed into law by each EU Member State by February 2018, it is recommended that radon issues have to be considered during the design phase of the building construction, particularly for NZEB applications. Further, external irradiation from building materials, i.e. tuff, marbles, tiles, pozzolana, coal ashes and so on, may be a reason of concern also.

This paper describes radiation protection issues focusing on public and domestic environments, where people are supposed to spend a considerable amount of time. About radon, real measurements are shown, both in domestic and working scenarios. Dealing with external irradiation due to building materials, calculations and simulations have been performed and results are presented.

Peer-review under responsibility of the scientific committee of the AiCARR 50th International Congress; Beyond NZEB Buildings

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1876-6102
Peer-review under responsibility of the scientific committee of the AiCARR 50th International Congress; Beyond NZEB Buildings
10.1016/j.egypro.2017.11.119

Keywords: radon; indoor gamma irradiation; radiation protection, dosimetry

1. Introduction

Today, energy production by renewable energies, low-carbon-emitting energy sources, together with energy savings, appear to be some key-approaches to a more sustainable future of the Earth planet.

Such efforts can theoretically be applied at every level, from a large industrial sector (e.g. electricity production, manufacturing installation, etc.) dealing with few plants that manage large quantities of energy, till people's dwellings, dealing with many customers managing a very small amount each.

Only in the last decade, such a culture has begun to be transferred in buildings industry also, developing new construction trends that include, starting from the design phase, solar panels for hot water or electricity production, wind generators, shadowing systems and optimized orientation to sun, thermal insulation materials, and technologies with improved performances, etc. All those strategies to minimize building's consumption and energy losses while maximizing its energy production, giving finally a net balance near to zero.

In such a contest, particular interest assumes the aspect of the indoor air quality: current trends tend to care about windows and doors' sealing, rendering the internal environment an air-tight system. In such a way, if a periodical air renewal (natural or artificial) is not present, internal air pollutants may build-up to concentrations-in-air that could be reason of concern to people's health.

Alongside chemical pollutants (e.g. combustion residues from kitchen fires or fireplaces, solvents from paints and finishing, etc.), radon gas plays the role of radioactive pollutant, being a noble gas that emerges from the ground or building materials, easily diffusing in structures and accumulating in closed environments. According the World Health Organization, WHO, radon is the second cause of lung cancer to the general population, being cigarettes smoking the first one. Epidemiological studies have provided evidence of an association between indoor radon exposure and lung cancer, even at the relatively low concentration levels commonly found in residential buildings [1]. The International Commission on Radiological Protection, ICRP, revised the risk assessment about radon in [2], confirming WHO concerns about residential exposure for the public in domestic environment. Such considerations were merged in the EU 2013/59 Euratom Council Directive, that introduced new recommendations to be transposed into law by each E.U. Member State by February 2018. In particular, the Directive introduces lower reference levels for radon concentration in air, and ratify the need for radon control not only for workplaces but for dwellings also. Moreover, the Directive introduces reference levels for gamma radiation emission from building materials.

Radon gas and typical materials used in constructions (tuff, marbles, granitoides, porphyries, pozzolana, glaze and stoneware tiles, bricks, etc.) are defined as Natural Occurring Radioactive Materials –NORM. When dealing with exposure to such radiation sources, special evaluations about delayed-in-time health effects are to be carried on. The current Italian law (D. Lgs. 230/95 s.m.i.) considers a radon annual-averaged concentration-in-air of 500 Bq/m^3 for working places as a reference value, resulting in an effective dose value of ~3 mSv/a (considering a conversion factor from concentration-in-air to effective dose of $3 \cdot 10^{-6}$ $mSv/h/(Bq/m^3)$ [3] and a residence time of 2000 h/a in working spaces). It should be noted that, currently, residential dwellings are not accounted for. From [4], the reference level for radon indoor concentration, including both working and residential, shall be lowered from 500 Bq/m^3 to not more than 300 Bq/m^3; in the meantime, a reference level for external exposure to gamma radiation emitted by building materials, including both indoor and outdoor contributions, is introduced and set at 1 mSv per year.

If the latest issue appears fairly new, radon pollution is known by a long time. In 1988, the Italian ANPA (the former ISPRA, The Italian National Institute for Environmental Protection and Research) and ISS (The Italian National Institute for Health) realized a survey campaign about radon indoor concentration in a sample of 5000 Italian dwellings. Such a campaign was a first screening only, because a sample of 5000 dwellings is surely not representative. Anyway, results reported in [5] have shown interesting reasons of concern: 1) radon issues are strongly related to local peculiarities (soil origin and constitution, microclimate conditions [6]) and building