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HARMONISATION OF DOSE MEASUREMENT PROCEDURES USING PASSIVE DOSEMETERS: USE OF PASSIVE H*(10) DOSIMETRY SYSTEMS IN EUROPE

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ABSTRACT

One of the outstanding tasks of the project 16ENV04 Preparedness, is to investigate the use of passive dosemeters aimed for measurement of operational quantity H(10). The aim of this task is to develop a rationale to harmonize the procedures used by European measuring bodies and authorities, which provide services or fulfil tasks in radiation protection by using passive H*(10) area monitoring systems. Procedures used by European measuring bodies and services for environmental monitoring using passive area dosemeters are investigated, with a goal to investigate the applicability of passive dosimetry systems in the aftermath of a nuclear event.*

1. Introduction

The protection of the public against ionizing radiation and radioactive contaminations caused by nuclear or other radiologically relevant incidents or accidents (i.e. events), including terrorist attacks, is of major importance and may affect thousands of people. Following a radiological event, radiation protection authorities and other decision makers need quick and credible information on affected and contaminated areas. Therefore, the *16ENV04 Preparedness* project (European Union's Horizon 2020, EMPIR Environment Call, 2017-2020) [1] was designed to develop reliable instrumentation and methods needed in the field of preparedness, so that correct decisions on countermeasure will be possible. Among other activities, the project will further work on improving methods for long-term monitoring. The results of this project will enable an adequate response for the protection of the public and the environment against dangers arising from ionizing radiation during and in the aftermath of a nuclear or radiological event.

The overall objective of this project is the establishment of a metrological basis to support adequate protective measures in the aftermath of nuclear and radiological emergencies. To achieve this, the specific objectives of this project are:

1. To develop unmanned aerial detection systems installed on aerial vehicles and helicopters for the remote measurement of dose rates and radioactivity concentrations. In addition, to establish novel methods applicable to core and remote areas of a nuclear or radiological incident for air-based radiological

measurements including dose rates, radioactivity concentrations, traceable calibrations for the determination of ground surface activities and interpretation methodologies for Rotary-wing Unmanned airborne monitoring system (RWUAMS) or helicopter based radiological measurements.

2. To develop transportable air-sampling systems for immediate information on radioactive contamination levels in air. This will include generating industry appropriate pre-production models of modular and portable air-sampling systems based on gamma spectrometric detectors that can be quickly transported to places of interest.
3. To investigate the metrological relevance of 'crowd sourced monitoring' data on dose rates and provide recommendations on the usability of such data. In addition, to develop handy detector systems with the potential to be used as dose rate measuring instruments in governmental and non-governmental applications.
4. To establish stable and reproducible procedures to measure ambient dose equivalent rates using passive dosimetry in order to harmonize passive dosimetry for environmental radiation monitoring across Europe.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (instrument manufacturers, accredited laboratories), standards developing organizations (ISO, IEC) and end users (national nuclear regulatory bodies, decision/policy makers e.g. IAEA, European Community Urgent Radiological Information Exchange (ECURIE), OECD/NEA, EURADOS, UNEP, WHO, WMO).

The project consists of 17 partners and 6 collaborators, working on accomplishment of the above mentioned objectives. The project activities are organized in four work packages (WP):

WP1: Unmanned aerial detection of radiological data
WP2: Transportable air-sampling systems
WP3: Monitoring of ionizing radiation by non-governmental networks
WP4: Passive Dosimetry

The objective of this paper is to present activities carried out under the WP 4 related to measurements of ambient dose equivalent rates using passive dosimetry.

2. Passive dosimetry in Europe

In Europe, there are approximately 100 dosimetry services e.g. governmental offices, companies, and institutions associated with a research facility or a hospital, using different passive area dosemeters (dosemeters without inbuilt electronics) for environmental monitoring. Due to the lack of international standards, a variety of different measurement procedures and uncertainty calculation methods are used. The application of passive detectors for radiation protection is not a trivial task. Due to the natural background radiation, it is difficult to verify the compliance of measured data with the limits of the effective dose defined by the European Basic Safety Standards outlined in the Directive 59/2013 [2] or radiation protection, e.g. 1 mSv per year for the public.

A recent survey by the EURADOS (www.eurados.org) Working Group 3 (WG3-Environmental Dosimetry) [3], showed that some of these services are neither traceable to primary dosimetric standards nor accredited. The survey addressed the following topics: main radiological characteristics of the dosimetry systems, dose

assessment methodology, different aspects of quality assurance including accreditation, other services provided by laboratory and participation in the intercomparisons. Within the survey, 60 questionnaires had been received from 47 different institutions and 24 different countries. The vast majority of dosimetry systems (86%) used for environmental monitoring were photon dosimetry systems. As regards the dosimetry systems, the systems are based on thermoluminescent (TL) detectors in 83% of the cases, followed by radiophotoluminescent detectors (RPL) in 7% of the cases. To a lesser extent, optically stimulated detectors (OSL), direct ion storage detectors (DIS), CR-39 and fission track detectors are used [3]. LiF:Mg,Cu,P emerged as a material with significant advantages over LiF:Mg, Ti for environmental dosimetry applications, due to 30 times better sensitivity, than LiF:Mg, Ti, however, later are still commonly used. The average lower limit of the stated dose range was 54 μSv, whereas the stated lower energy range in different laboratories was from 5 keV to 100 keV [3].
The findings of the survey revealed that in terms of dose calculation procedures, the dosimetry services apply transport dose corrections in half of the cases, only 30% of the services subtract the natural background and in 43% of cases the dosimetry services apply fading correction factors [3]. Most of the laboratories (83%) calculate the overall measurement uncertainty and have Quality Management System in place. Overall conclusion of the survey highlighted a further need for a harmonization in the field of environmental dosimetry using passive detector systems. Some open questions have been identified, e.g. concerning the harmonization in terminology, uncertainty assessment procedures or corrections of measured dose values due to transport and climate [3].

3. Basic properties of passive dosimeters used in Europe

As mentioned above, TL detectors are the most common systems used in Europe. Among TLD systems, different types of detectors are used such as: LiF:Mg,Cu,P, LiF:Mg, Ti, CaF_2, $CaSO_4$, etc [5,6]. Their basic properties are given in the Table 1.

4. Passive dosimetry within the project 16ENV04 Preparedness

As harmonization is urgently needed even in routine monitoring, recommendations and guidelines will be elaborated within the project *16ENV04 Preparedness* which will serve as a basis for the development of international standards. For nuclear and radiological accidents, the feasibility of follow-up surveillance using passive dosemeters will be investigated and conclusions will be drawn.
The aim of this work package is to establish stable and reproducible procedures to measure ambient dose equivalent rates using passive dosimetry in order to harmonize passive dosimetry for environmental radiation monitoring across Europe. In the aftermath of a nuclear or radiological event, long-term monitoring of external gamma-doses may be performed by using passive detectors. Passive detectors are small, cheap and robust, and do not need an electrical power supply, so that they can be placed anywhere. However, the metrological correctness of the dose data obtained from these detectors is a presupposition for the application of such detectors in official measurements, which may lead to far-reaching decisions in radiation protection of the public.

Table 1. Common passive dosimeters used in Europe.

Phosphor	CaF_2:Dy	CaF_2:Mn	LiF:Mg,Cu,P,	LiF:Mg, Ti
Detector Form	chip	chip	chip	chip
Dimensions (mm)	3.2 × 3.2 × 0.9	3.0 × 3.0 × 0.9	3 × 3 × 0.9	3.2 x 3.2 x 0.89
Energy Dependence	±30% of ^{60}Co from 50 to 1500 keV	±10% of ^{60}Co from 70 keV to 1250 keV, 25% of ^{60}Co @ 40 keV	±20% from 20 keV to 1250 keV, 140% of ^{137}Cs @ 40 keV	-
Dose range	0.1pSv to 1Sv	0.1pSv to 1Sv	10 pSv – 10 Sv	10 pSv – 10 Sv
Fading	10% in 1st 24 hr 16% total in 2 weeks	8% in 1st 24 hr 12% total in 2 weeks	5%/y at 20 °C with anneal	5%/y at 20 °C with anneal

To address these issues, investigations of the current status of passive area dosimetry systems used for environmental monitoring will be performed in Task 4.1. This will be done by compiling available information and by performing a comprehensive intercomparison. In Task 4.2, methodological studies and extended measurements will be carried out to explore the properties and detection limits of passive dosemeters used for environmental monitoring. In Task 4.3 it will be investigated as whether a different detector type, electret ion chambers, could replace common passive dosimetry systems in the future. In Task 4.4, a conclusion will be drawn concerning the applicability of passive detector systems in the framework of preparedness. In addition, harmonized measuring and calibration procedures will be recommended to achieve a European comparability of passive area measurements.

5. Conclusion

A need for a harmonization in the field of environmental dosimetry using passive detector systems is evident. WP 4 of project *16ENV04 Preparedness* will contribute to the evaluation of properties of passive dosimeters along with recommendation for harmonization of measuring and calibration procedures of passive area dosimetry systems.

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7. Literature

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HARMONIZACIJA PROCEDURA ZA MERENJE AMBIJENTALNOG EKVIVALTA DOZE: PRIMENA PASIVNI H (10) DOSIMETRIJSKIH SISTEMA U EVROPI

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SADRŽAJ

Jedan od zadataka projekta 16ENV04 Preparedness je ispitivanje pasivnih dozimetrijskih sistema namenjenih za merenje operativne dozimetrijske veličine H*(10). Cilj ovog zadatka je evaluacija i harmonizacija procedura koji koriste laboratorije u Evropi a odnose se na merenje ambijentlnog ekvivalenta doze, a u vezi eventualne primene ovakvih doziemtrisjkih sistema u kontekstu dleovanja u vanrednom događaju.