Requirements on official electronic dosimetry systems - a concept for the use of official electronic personal dose meter in Germany

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Abstract:
Due to their technical features electronic personal dose meters offer a variety of advantages to their users compared to the use of passive dose meters. Therefore in Germany an initiative was started by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety to promote the use of electronic personal dose meters as official dose meters and as an alternative to the existing passive dose meters. In this presentation the concept of official electronic personal dose meters, which has been developed by Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH on behalf of the German Ministry for Environment, Nature Conservation and Nuclear Safety will be explained. Hereby focus will be given also to features of the concept which allow dose estimations in the European context for transient workers.

1 INTRODUCTION AND BACKGROUND

Up to now in Germany according to the German radiation protection ordinance (StrlSchV, [1]) and according to the X-ray ordinance (RöV, [2]) passive dose meters (e.g. TLD, film) only are accepted by the competent authorities to measure the official effective dose. The high quality and reliability of these passive dose meters and of their analysis have been proven over several decades so that the determination of the effective dose of occupationally exposed persons is sound.

Nevertheless the demand of task related dosimetry and automation enforced developments in the last few decades of reliable electronic personal dose meters (EPD) which are based on one or more detection probes which can be read out directly without any chemical or physical (like thermal) pre-processing. Typically these dose meters consist of the detection probes and additional electronics and signal processing to allow a direct reading of the dose results. With respect to the passive dose meters EPD offer some advantages which on one hand contribute to a better exposure control and on the other hand foster the development of a sound culture in radiation protection due to direct feedback of dose information. Some of these advantages are:

- lower detection limits and improved resolution
- immediate read out of the measured dose
- no need for chemical or physical pre-processing to get the dose information
- availability of dose and dose rate information, in addition: threshold alerts for dose and dose rate
- possibility to preset levels and thresholds by the dosimetric system
- further features for internal tests and additional information storage

Currently the use of EPD, especially of direct reading electronic personal dose meters, is limited to operational dosimetry in Germany. Typically EPD are applied in addition to the official passive dose meters in large nuclear installations and facilities like nuclear power plants, facilities of the nuclear fuel cycle, large research centres or in large hospitals. The reason of this parallel dosimetry may be due to the obligation to use these additional dose meters because of license conditions or because the organisation is interested in an on-time knowledge and feed back of the current personnel exposures. Many improvements in the reduction of the exposure of personnel for example in German nuclear power plants have been achieved based on task related exposure information which became available from EPD (see for example [3], [4]). Moreover, for contracted workers in Germany a radiation passport has to be maintained which shall provide up to date information on the current individual dose of the owner of the passport when starting to work in a nuclear facility. This up to date information bases on the results of the official dosimetry with its official passive dose meters. But due to the processing times the results of the official dosimetry may not be available when changing the work place from one plant to the next. So the passport also documents the results of the operational dosimetry from EPD for the time in between, as this information is available in time when

leaving the plant. Thus even actually EPD to some extent contribute to the official system of controlling the exposure of workers in controlled areas.

Due to the advantages mentioned, but also due to additional reasons as e. g. to reduce the costs for the determination of the effective dose by avoiding the use of two or more personal dose meters at a time (but without compromising the requirements of the radiation protection) the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU) initiated a project to introduce EPD as official dose meters forming an alternative to the official passive dose meters. The project was split into two parts: part one focused on the development of a general concept on how to design an official dosimetry system with EPD, which shall fulfil the legal requirements for the determination of the effective dose according to the relevant ordinances (RöV, StrlSchV). In part two as a pilot project the implementation of the concept is addressed and first experiences shall be derived. The later implementation of electronic dosimetry systems as official dosimetry system depends on an approval by the BMU and the authorities of the States ("Länder"). The results of both parts of the project will provide the basis for such an approval.

In part one the general concept was developed in 2004 by Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH under the supervision of the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS). The results are subject of this presentation. Part two of the project was launched in autumn last year and more details will be presented in the paper presented by Mr. Martini in this workshop.

2 OBJECTIVES OF THE CONCEPT

Emphasis in the concept of the dosimetric system is given to the overall composition of those components, which are necessary to measure the effective dose, to read out the measured date from the dose meter, to transfer the data to a competent evaluating organization and to deduce the effective dose from the measured data. Requirements due to the German regulatory system and the different conditions, under which such an electronic dosimetry system may be operated, have to be taken into account. A rough overview on the requirements will be given below.

The concept does not consider aspects on the quality and on the physical properties of the dose meter probes used in the EPD. It is proposed that dose meters used in the system must have passed a type-test and a type-license of the Physikalisch-Technische Bundesanstalt (PTB), will be compliant with the international standard IEC 61526 (see [5]) and will be appropriate to the environmental situation in which they are intended to be operated. Nevertheless, as a result of the concept an adaptation of the relevant PTB standards seems necessary, but the related recommendations are not part of this presentation.

Requirements due to the German regulatory system

Requirements to be taken into account due to the German regulatory system are laid down in radiation protection relevant ordinances, i. e. StrlSchV and RöV, in the law and the corresponding ordinance on the type-test and type-license (and related PTB standards) and in radiation protection relevant BMU regulations, which are applied by the German state authorities when transferring general requirements of the ordinances into the practical case. Moreover, several national and international standards and recommendations of the German radiation protection commission (Strahlenschutz-Kommission, SSK) shall be taken into account. Due to the scope of this presentation the requirements can not be discussed in detail but instead the following list may give an overview on the issues treated:

- physical properties of the dose meter probe and the dose meter (incl. avoiding and recognition of malfunctions and failure)
- security against manipulation of the measurement by the wearer of the dose meter
- documentation of the properties and the use of the dose meter
- identification of the dose meter and allocation of the dose meter to its wearer
- operational conditions for the use of the dose meter
- analysis of the measured effective dose (including e.g. investigation levels and in case background subtraction) by the competent evaluating organization
- duration of the surveillance period

- quality assurance (for the dose meters as well as for the competent evaluation organization according to StrlSchV and RöV)
- reliability and availability of dosimetry systems (incl. data transfer)

It has to be mentioned, that some of these requirements are currently valid for passive dose meters and their corresponding evaluation systems (e.g. concerning data transfer) so during the elaboration of the concept either corresponding requirements had to be developed or it had to be proven that issues could be skipped for EPD.

A basic set of requirement to be fulfilled by an electronic dosimetry system and reflecting the different technologies of EPD and passive dose meters was formulated end of 2003 during the common meeting of the working group on radiation protection of the BMU, the State authorities (Fachausschuss Strahlenschutz des Länderausschusses Atomkernenergie, FAS), the working group on Röntgen of BMU and the corresponding States authorities (Länderausschuss Röntgenverordnung, LARöV). The dosimetric system shall satisfy the demands on

- correctness of the data over the full data chain (starting with the EPD and ending with the validated monthly effective dose, provided by the competent evaluating organization),
- completeness of the data over the full data chain,
- security against any data manipulation over the full chain and
- safety of the data against any unauthorised access.

It should be mentioned, that these basic requirements reflect the "lessons learnt" from international experiences as well as PTB requirements of 1995, which up to now are not implemented in the PTB standards, but are under discussion.

Requirements due to the different conditions of operation

A second group of requirements results from the different frames in which an electronic dosimetry system may be operated. As mentioned in the introduction currently the use of such a system is under discussion for a large variety of installations and facilities. Especially for nuclear power plants, for large hospitals or for research centres the system shall be operational, i.e. the concept shall take into account the similarities but also the differences.

In ***German nuclear power*** plants EPD are used in the context of the operational dosimetry. The dose meter is taken from a dose meter pool by the wearer just before entering the controlled area and is returned to the pool after having left the controlled area ("pool concept"). When leaving the controlled area the measured dose information are read out from the dose meter and stored in the central operational dosimetry system. To allow a later processing and analysis of the measured effective dose an allocation of the supervised person, i.e. of the wearer, and of the dose meter is performed during the entry; typically an identifier of the wearer is stored in the dose meter when entering the controlled area and is transferred together with the read out measured data, when leaving the controlled area. The "pool concept" benefits from the rigorous access control which is established at all entries to controlled areas - neither entering nor leaving of a controlled area is possible without passing an access control system (e.g. by a turnstile).[1] Thus it can be ensured by technical means to retrieve the personal identifier of the wearer during entering the controlled area and to readout the dose meter when leaving the controlled area. If information are not provided by the wearer (or malfunctions occur) access or passage is denied and the radiation protection staff can become active.
Typical to the situation in German nuclear power plants is that in general only one (large) controlled area does exist, which has to be supervised and for which a central access to enter and leave this area does exist. Nevertheless in addition some de-central controlled areas (e.g. for interim storages) may exist, which are not as frequently entered as the central controlled area, but which have to be taken into account, too, in the concept of an electronic dosimetry system.

[1] For the rare cases in which no hardware based access control does exist (e.g. temporarily existing controlled area during preparation of radiactive transports) organizational and administrative procedure ensure the control of access.

In ***research centres*** or in ***large hospitals*** the situation tends to be different compared to the situation in nuclear power plants. Typically no access control systems do exist to steer the entering and leaving of the controlled area. As a consequence it is difficult to ensure that a dose meter is worn by the personal to be supervised. Based on a missing access control there are only limited means to ensure that dose meters are worn. But it has to be stated that this problem does not depend on the dose meter type: even at present it may be a problem to assure that personnel will wear passive dose meters.
In addition, the number of (frequently entered) controlled areas is much higher in research centres and hospitals and these areas often are located at different places of the buildings or the campus. Moreover, the number of qualified personal available in charge of radiation protection is much lower than in nuclear power plants. This results in the high need of a reliable and centralised radiation protection surveillance system including official dosimetry. If an access control can not be established (e.g. in case of interventional medical treatment applications) a permanent allocation of an EPD may be an supporting alternative to the "pool concept" present in the nuclear industry sector.

3 CONCEPTUAL APPROACH – THE CONCEPT

3.1 Overview on the concept

The concept shall cover all important conditions of operation, i.e. the different options of access control, the "pool concept" as well as implementations, in which the EPD is permanently (with respect to an entry of a controlled area) allocated to a wearer. In this paper, however, the scope of the presentation will focus on the "pool concept" with access control, which is expected to be the typical concept used in nuclear power plants. Nevertheless some recommendations are given for a concept with permanently allocated dose meter, which is regarded to be a good solution when an access control is missing.

The data flow in the GRS concept for an official electronic dosimetry system in the "pool concept" layout is sketched in Figure 1. It shall be noted, that the figure represents the situation for utility personnel; for outside personnel some amendments are necessary to direct the evaluated dose data to those organizations responsible for the outside personnel according to StrlSchV and RöV (please refer to chapter 3.2).
Some formal remarks are necessary which will help to understand the figure more easily: those data transfer lines, which correspond to the transfer of data of the official dosimetry system, are marked in red colour. Those data transfer lines, which are part of the operational dosimetry system and in principle are out of the focus of the official dosimetry system, except that they shall not influence the official dosimetry system in any way, are coloured blue. Data transfer lines in green or black correspond to the transfer of data from the competent evaluation organization to the responsible person of the controlled area or to the competent authorities. Finally clouds symbolise those parts in the concept, which are needed from a functionality point of view but for which no dedicated requirements, esp. concerning technological aspects exist, i.e. the technical layout of that functionality represented by a cloud is completely subject to the implementer's decision.

In case of the "pool concept" in a nuclear power plant EPDs shall be used, which in Germany have passed a type-test and a type license of the Physikalisch-Technische Bundesanstalt (PTB). These devices will be provided from a pool of dose meters at the entrance of the controlled area. Active EPD will be used, if due to operational needs features as e. g. direct readability of the dose, preset of alarm levels for dose respectively dose rate or additional data (dose rate sequences, maximum of dose rate) are necessary in addition to the pure determination of the individual effective dose. The application of passive EPD seems possible, if only simple demand, e. g. supervision of routine activities, rests on the measuring task.

If the dose meters are supplied from a pool, the dose meter will be assigned to the porter in a reader station (EPD-reader, dose meter terminal) when the person enters the controlled area. A unique personal ID will be used to identify the porter; this ID will be stored in the EPD. If an exchange of the EPD cannot be excluded due to the way how the porters wear the EPD, the personal ID can be used to identify the assignment to the porter either by displaying the ID or by implementing special readers for identification in the controlled area. The EPD fulfils special requirements regarding safety against loss of data or manipulation of data. In addition it will store the information on battery changes and can not be switched off by the porter. These demands will also be part of an extended type-test.

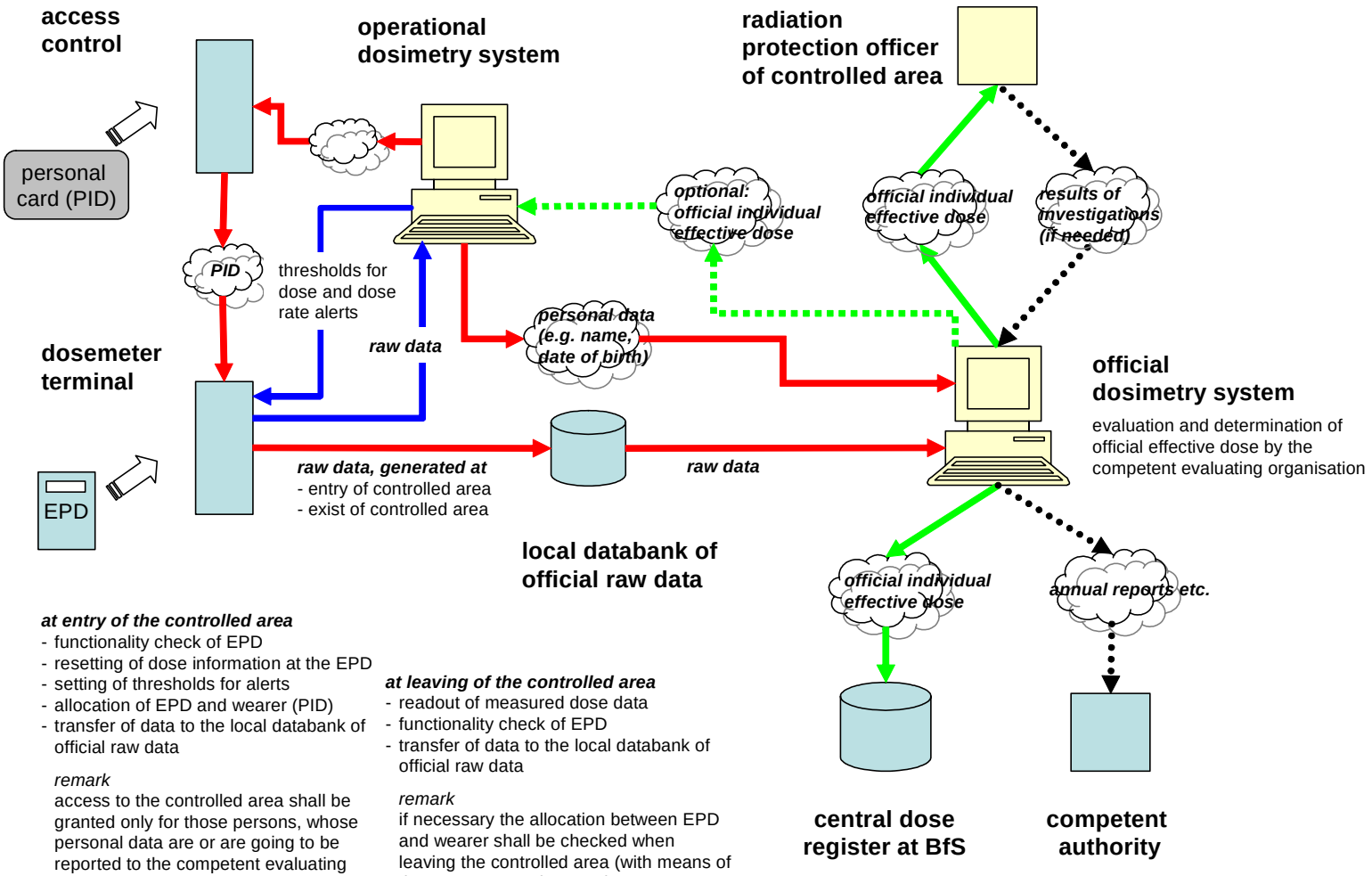

Figure 1 Data flow in the GRS concept for an official electronic dosimetry system with use of pooled EPD. The data flow is sketched for facility personnel; for outside personnel some amendments are necessary (for further details please refer to chapter 3.2)

During the set up of the dose meter in the dose meter terminal for the entrance of the controlled area a functional test will be carried out. To store the porter's ID to the EPD the personal-ID has to be delivered to the EPD reader by a special dedicated station (e. g. the reader of the identity card) or by a terminal to type in the code.

The data sets retrieved when entering and leaving the controlled area which both are needed to evaluate the contribution to the porter's official effective dose, both contain the identification number of the EPD, the personal ID, the time of access of the controlled area, and the positive result of the functional test of the dose meter performed. If passive EPD should be used in a pooled system, the dose actually stored in the dose meter (if not reset) needs to be transferred to a database, too, to allow for the later calculation of the dose received.

The design of the system assures that the official branch of the data and the data stream cannot be interfered with by the operational dosimetry system. The de-coupling of the operational and the official dosimetry system takes place at the dose meter terminal. From there, the data – if necessary after a short interim storage – are transferred to a local intermediate storage system, which acquires the data, stores them for intermediate storage, archives the data for a certain time period and makes the data available for transfer to the competent evaluating organization. This local station is called the "local databank of official raw data" and is represented by a local IT-component in the responsibility of the competent evaluating organization. Including its interfaces with the dose meter terminal, it must be certified according to international technical rules. The interfaces to the dose meter terminal and to the competent evaluating organization including the data transfer via these interfaces will be surveyed and protected against data losses and data manipulation by adequate transfer lines and protocols. To the timely limited local archiving of the raw data in addition there will be also an additional possibility of a later access to these data.
If the dose data have to be retrieved for de-centralized controlled areas as e. g. this may be the case in hospitals, research institutes but also in some nuclear facilities, the data sampling may be performed by a sufficiently secured local area network (LAN) including a router, which supplies the data to the local data base. This solution certainly has to meet the high demand on the safety against and recognition of data losses and on avoiding data manipulation.

The IT-system of the local data base addressed above shall be power-safe (e.g. by a battery driven emergency power) and shall consist of mirrored processor/disk-systems to increase the safety against data losses. The system stores each data set of entrance and leaving the controlled area to assure the possibility to combine the data sets but also to be able to identify missing data sets.

During the stay in the controlled area the EPD stores the dose received and furthermore additional data as e. g. the results of permanently executed internal self-testing procedures of the EPD, dose rate data and data of additional dose meter probes installed inside the EPD.

When leaving the controlled area with a pool-type dose meter (or with a dose meter which needs to be read out each time when leaving the controlled area[2]), all data are read out and transferred to the operational dosimetric system. In parallel and de-coupled from the operational dosimetric system all data necessary for the official dosimetric system (for data analysis same as for validation) will be supplied to the local data base of official raw data. The transfer will be guarded against loss of data. The data supplied especially cover the personal ID, the ID of the dose meter, the flags representing the results of the internal self-testing, the time of leaving the controlled area and certainly the measured dose data and relevant information that may be important to validate the data. The personal ID and the ID of the dose meter are important to be able to join the data set of access and exit as well as to correlate the personal data of the dose meter's porter during analysis. The data addressed will be stored in the local data base and will be made available for the later transfer to the competent evaluating organization. In addition these raw data are stored for some time locally. This storage aims at the possibility to have access to the raw data for some time. It does not cover the demand to archive the data by the evaluating organization according to the German regulations, which will be done at the premises of the competent evaluating organization.
The official raw data will be encoded and sent to the competent evaluating organization in regular time intervals defined by this organization. The data transfer will be secured against data loss and manipulation by

[2] This may or may not be necessary for a passive electronic dose meter, especially if it is assigned permanently.

dedicated transfer protocols. The competent evaluating organization addressed within this concept is a certified organization which is approved by the competent authority for this task. This organization provides competent, qualified and experienced staff, which is responsible for the data retrieval and transfer, the check and evaluation of the partial (raw) data received and which accumulates the partial data to the official dose for the surveillance interval prescribed. For this task the organization will make use of all partial data received. The organization is responsible for the full chain of data retrieval and transfer from the dose meter terminal (reader) via the system of the local data base to the final destination in system of data evaluation at the site of the competent evaluation organization. This organization will not necessarily be responsible for the EPD, as these are a part of the operational dosimetric system of the organization operating the controlled area and may be in that responsibility. It is, however, considered possible that the organization responsible may charge a qualified organization/company with the operation of this (operational) part of the system to provide for maintenance, tests and calibration according to the national regulation. In any way it has to be assured that all information important in this field has to be supplied to the competent evaluating organization.

As the result of the dose evaluation the competent evaluating organization delivers the official doses to the competent radiation protection officer, to the competent authorities and to the radiation protection register of the Federal Office for Radiation Protection (BfS). If necessary the competent evaluating organization will initiate evaluations by the radiation protection officer of the controlled area.
To fulfil its duties, the competent evaluating organization will need additional data from the organization operating the controlled area. These for example are personal data for each supervised person. The data may be delivered on different channels agreed upon between the evaluating organization and the organization operating the controlled areas.

As mentioned in the introduction, it has to be kept in mind that plants and institutions may differ in the layout and number of their controlled areas and especially in the access control conditions for these areas: for nuclear power plants the access to the controlled areas is quite formalized and technically secured – the previously explained “pool concept” takes strongly credit from this.

In contrary to this in hospitals and research organizations a large number of access locations and controlled areas may needed to be operated, which only in rare cases are technically secured e. g. by turn stiles. Thus usually no real access control is established. From the technical point of view the data retrieval in that situation of controlled areas was previously addressed. It may be performed in a similar way using several reader terminals linked by a secured LAN. In case of missing technically secured access controls organizational and administrative measures and personnel responsibility have to be used and taken credit of to ensure a proper allocation of EPD and their regular readout. If a “pool concept” shall be implemented the administrative and organizational measures have to assure that the dose meters are used and the necessary functions are activated when entering and leaving the controlled area. With respect to the degree of effort related to these administrative and organizational measures for a pool concept, it seems more reasonable and effective to permanently allocate an EPD to a wearer and to establish processes to ensure a readout of the dose meter at the end of a certain surveillance period. It has to be noted that the processing of the EPD data in this case shall be the same as in case of the “pool concept”.

3.2 Dosimetry of outside workers in the European context – the approach within the concept

In Germany according to StrlSchV and RöV the responsibility for ensuring, that the dose limits are obeyed for outside personnel is with the responsible person of the company which delegates the personnel into the foreign controlled area (so called “dispatching company”),. As a consequence and, moreover, as clearly stated in both ordinances the responsibility for the determination of the individual effective dose is with the responsible person of the “dispatching company”, too. Therefore up to now all outside worker wear passive personal dose meters in addition to the dose meters of the controlled area, These passive official dose meters are distributed by the official competent dosimetry company related to the “dispatching company”, to measure the official effective dose.

In the previous chapter the concept of the use of EPD for personnel, belonging to the controlled area (utility personnel), was discussed. With some modification and enhancement at the part of the competent evaluation organization the concept can be adapted in a way, that the use of official EPD will be of benefit for

“dispatching companies”, too, i. e. that EPD may replace official passive dose meters at “dispatching companies”.
If outside personnel will only be detached to plants using EPD as official dose meters, with the agreement of the competent authorities of the workers’ “dispatching company” it is possible to use the official EPD of the organization of the controlled area instead of passive official dose meters of the sending company. It has, however, to be assured that the summing up of all exposure data from different controlled areas for the period of survey can be performed by the competent evaluating organization related to the sending company. This for example can be implemented by sending the partial data related to each controlled area and evaluated by the corresponding competent evaluating organization of the controlled area to the competent evaluating organization of the “dispatching company”. shows the sketch of the related data flow. It has to be noted, that all relevant personnel data needed to send the individual dose data of a visit of the controlled area (including information on the competent evaluating organization of the “dispatching company”) is available at the competent evaluating organization of the controlled area.
For staff of “dispatching companies”, which becomes active in companies with official EPD **and** in companies with official passive dose meters, it will not be as easy to use EPDs as official dose meters. In this case – as usual and current standard in Germany - passive dose meters supplied by the “dispatching company” to its staff will have to be used. In this case, however, it will be necessary to flag the electronic data of the EPD, which will be used in addition to that passive dose meters at least for operational dosimetry reasons, as operational dose meters to exclude them from the official data evaluation at the competent evaluating organization.

Although up to now only discussed in the German context it is obvious, that the transfer of the effective doses due to the visit of a controlled area is not limited to German competent evaluating organizations but is also possible to foreign organizations involved in official dosimetry, as far as the EPD approved by BMU and the states authorities are regarded to be qualified for official dosimetry in the respective European country of the “dispatching company”.

4 SUMMARY AND OUTLOOK

In the presentation the German concept on the use of electronic personal dose meter as official dose meter according to the German radiation protection ordinance and of the X-ray ordinance was explained. The concept was developed to cope with the special situation in nuclear power plants same as in large hospitals or research centres. Up to now electronic personal dose meters were used as operation dose meters, but it could be shown that the use of EPD is possible as an alternative to official passive dose meters thus resulting in the introduction of state of the art technology into the official dosimetry in Germany with benefits on the hand of dosimetry same as on the hand of economics.

The concept is as flexible to take into account the use of official EPD by outside workers, too. Thus the benefits are not limited to the organization of the controlled area but to the “dispatching company”, too. This will improve the radiation protection for outside workers from Germany same as from other European countries. With the concept of official EPD a first step has been made to introduce new IT technologies into the official dosimetry in Germany, too.

It should be stressed, that the concept does not fix technical details, but mainly gives a certain frame which has to be filled with technical details considering the main guidance on data safety and reliability.

Currently the implementation of the concept is under progress. In the frame of project consisting of several pilot implementations the technical realisation of the concept is performed and several technical and IT-solutions are under discussion for implementation. As a result the project shall provide a sound basis to approve the implementation by BMU and the state authorities. In addition “lessons learnt” shall be drawn from the experiences made, including, if necessary, amendments and technical realisations of the concept presented here.

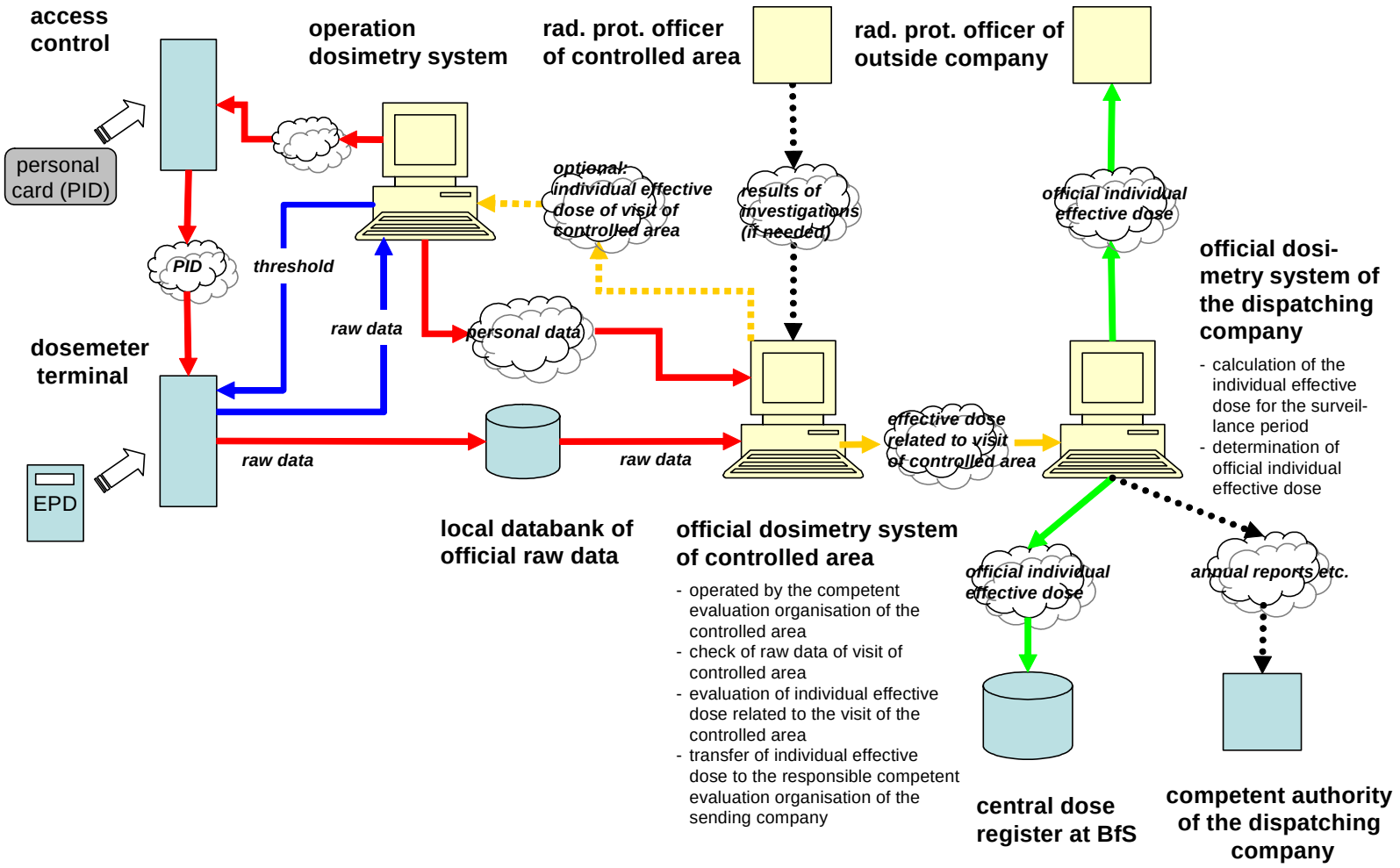

Figure 2 Data flow in the concept for an official electronic dosimetry system with use of pooled EPD for dose measurements for outside workers.

A next major step to improve further on the performance of radiation protection for outside workers on a European level, will be the development of a European radiation protection passport. During the presentation the fundamental importance of the radiation passport for the radiation protection of outside workers was mentioned. In German, same as in other European countries, that passport is a paperback which requires a lot of effort to maintain, esp. by manual none-automated transfer of measured dose data and by transfer of personal data to the dosimetry systems at the operating organizations. To reduce the risk of data transfer same as to reduce the associated effort and to improve the processing times to get up to date data via the radiation passport an electronic European radiation protection passport should be discussed and focused on. Concepts may vary from

- radiation passports, which contain all information including the dose information, which are loaded to the passport, when the owner is leaving the organization of the controlled area, to
- radiation passports, which only contain an identifier unique in Europe, which allows to get all relevant information from a national or European central radiation database, which contains all dose information including those of the last visit of a controlled area (it is obvious, that this concept requires the use of EPD for all outside workers)

It's the hope of the authors that further effort will be made to develop electronic radiation protection passports on a European level and thus to set the individual dosimetry onto a modern and effective system.

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