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Braunschweig und Berlin

F. Wissmann, R. Behrens, N. Greif, J. Roth, H. Schrepf

Requirements placed on computer programs for calculating the radiation exposure of flight personnel

Prepared on the basis of the Recommendation of the Radiation Protection Commission:

Determination of the exposure of flight personnel to cosmic radiation

1   General

Before a computer program for the determination of the effective dose may be used as provided by section 103 of the Radiation Protection Ordinance, it must be approved by the relevant authority – in this case, by the federal Civil Aviation Authority. For approval, the prerequisites defined by the Physikalisch-Technische Bundesanstalt (PTB) which are comparable to those valid for other dosimetric procedures must be complied with. Approvals from other countries may lead to a simplified approval procedure. In the following, criteria will be defined on the basis of which a first evaluation of computer programs is made. Special software requirements are described in section 3 of this paper.

The dose calculation carried out by the programs is assessed by a comparison with measured data. The database required for this purpose can be established as follows: As a basis for the comparison, a selection of data from different air routes (distributed all over the world and in an altitude range between 6000 m and 15000 m), on which measurements of the ambient dose equivalent were performed in both the range of the solar minimum and the range of the solar maximum, is used. The dose rates measured at different flight altitudes are related to a mean flight altitude. The comparison values determined for this flight altitude are represented as a function of the cut-off rigidity R_c and thus in relation to the earth's magnetic field. This representation is used for the evaluation. Care must be taken that the statistical fluctuation of the measured values does not exceed a range of ± 30 % (= relative standard uncertainty σ according to DIN1319 with a coverage factor $K = 2$) around the mean value.

2   Functional requirements

The dose values calculated by a program to be evaluated may vary only within the fluctuation margin defined by the comparison data (see 1). The dependence of R_c is to be determined on the basis of different routes over a large range of the magnetic width B_m (from the equator to the pole region). This allows requirements for a program to be formulated. The first criterion is:

   A computer program for the determination of the dose at flight altitudes can be accepted if the calculated ambient dose equivalents dH^*(10)/dt lie, as a function

of the cut-off rigidity R_c, for all possible values of R_c in a range of ± 30 % around the mean values determined from values obtained by experiment.

Alternatively, the route dose can be determined as a cumulative dose from the start to the landing. For this purpose, dose values must be calculated on the basis of flight data from different flight routes. The second criterion is:

A computer program for the determination of the dose at flight altitudes can be accepted if the route doses calculated and measured for different flights do not differ by more than ± 30 % from the dose measured.

Only if it is guaranteed that criterion 1 or 2 is complied with, shall a computer program be checked for detailed software requirements.

Regular comparison flights (with the routes randomly selected) allow dose values obtained by experiment to be directly compared with the values determined by the user. This comparison covers both a check of the application of the computer program and a check of the way the user proceeds. This allows the correctness and reliability of the whole procedure to be checked. To allow the radiation exposure at flight altitudes to be reliably determined in accordance with recognized measurement principles, a measuring system must be made available by an independent institution.

3 Non-functional requirements

3.1 Program security

It must not be possible for the user to modify the computer program. Protection must cover both unintentional actions (e.g. maloperation in the interactive program parts) and intentional manipulations (manipulations by means of an editor).

When the computer program is started, a check sum (CRC-32) must be calculated by the program. The check sum must be compared with a theoretical value contained in the program code. If there is no match, the program must be interrupted with an error message (for example: "modified program version").

It must at any time be possible to check whether the program version used upon approval (or an approved subsequent version) is used. For this purpose, the check sum mentioned is used which must be displayed if and when required. The value of the check sum can then be compared with the value specified in the approval document.

3.2   Data security

To counteract any intentional or unintentional modification of data, for example by using a text editor, all relevant files must be provided with a CRC-16 check sum. Before the files are used, the program must check the check sums and, where appropriate, the identification.

3.2.1 Parameter values

This data type comprises values relevant to the dose calculation which must not be arbitrarily changed by the user or the program provider. These are, for example, functional parameters used in the hybrid method.

Each parameter set must be provided with an unambiguous identification (for example, consecutive number and date of creation of the data set). The complete parameter set must be protected by a check sum (see 3.2). This shows whether the parameters have in part or completely bean modified, exchanged or deleted. Before the parameters are used, the program must check the identification and the check sum.

3.2.2 Flight data

The flight data required for calculating the dose (date and time in UTC, terrestrial longitude and latitude, pressure altitude), additional flight information such as the starting and the landing airport and the flight number (identification of the flight) are to be combined into one single data set and provided with a check sum (see 3.2). If the flight data are entered manually, an unambiguous identification of the user entering the information must also be stored.

3.2.3 Parameters for describing the solar activity

The parameters used for the consideration of the solar activity must be combined into one single data set and provided with a check sum (see 3.2).

3.2.4 Calculation results

All calculation results, including the parameter sets used (incl. the program identification) must be redundantly stored. The data must be filed on two separate storage units and a check sum for error detection must be stored in addition. An error is detected by comparing the two files and checking the check sum. The file whose check sum complies with the check sum stored will be used.

For a subsequent personal assignment, it is important that the calculation can at any time be traced back via the flight number. The calculation results must be stored in data sets containing all other information required for subsequent evaluation or use. These data sets must contain:

- Dose value (ambient dose equivalent and effective dose)
- ID of the flight performed (see 3.2.2)
- Check sum of the solar activity data used (see 3.2.3)
- IDs of the other parameter sets used (see 3.2.1)
- ID of the computer program (check sum, see 3.1)
- Time stamp of the evaluation.

For displaying the result of the dose determination, an approved software module must be available which may be a component part of the computer program. When data are assigned to persons, protection of these data must be ensured.

3.3 Error detection

By means of a plausibility check of the input data, it must be prevented that physically illogical values lead to a result. This must apply to both the parameter values and the flight data. Hence, the program must, for example, check the flight data as to whether the geographical coordinates comply with the starting place and the destination and whether the values lie within a reasonable interval. The flight altitude (pressure

altitude) may lie only in a defined range of values. Also, the dose calculated must be checked. If a value does not pass the plausibility check, the calculation must be aborted by an error message. The same applies to the ambient dose equivalents or route doses calculated.

3.4   Interfaces

All interfaces (for example: hardware interfaces such as the keyboard as well as software interfaces) exchanging data with the computer program, must be non-reactive. This means that all instructions received via the interfaces are allowed to influence the parameter values and the calculation result only in a permissible way. All instructions must be clearly defined and interpretable by the computer program. Non-defined instructions must be recognized as invalid and must not exert any influence on the result.

4   Documentation requirements

4.1 Requirements placed on the user documentation

The program and the documentation must be in compliance. The program documentation must be detailed and readily comprehensible (operating instructions, manual). This requires a description of how to use the program (in the interactive mode) as well as an exact description of the input data, parameters and calculation results. All available functions must be described: the specified ranges of values of the parameter data as well as the ranges of values of the flight data.

If accessibility to databases is given, for example, via a separate data interface, the data structure of the program input and of the program output must be clearly defined and documented. This must meet the requirements for the data format defined by the authority responsible. The type and amount of data, to be forwarded to the Luftfahrt-Bundesamt or to a body determined by same to be passed on to the Radiation Protection Register are defined in section 103, para. 8 of the Radiation Protection Ordinance in conjunction with section 112, para. 1, Nos. 2 and 3 of the Radiation Protection Ordinance. These data are the effective dose, information about registered radiation passports and the respective personal data (family name, first name, date and place of birth, sex), occupational characteristics and exposure conditions as well as the address of the person engaged in accordance with section 103.

4.2   Documents to be submitted for approval by the provider

The following documents are required for the approval procedure:

(1) For the functional requirements:

- Documentation of the physical background, the physical models used and the calculation methods applied. The descriptions must be detailed and comprehensible. If the method relates to experimental results, these must be quoted (only in publications accessible to the public). If the calculation is mainly based on physical simulation, the method used must be published in professional journals.

- List of the valid ranges of values of the flight data used (pressure altitude, geographical coordinates, date).

- Description of the plausibility check of the input parameters and calculation results.

(2)   For the non-functional requirements:

- The installable program which will be executable after installation.
- The documentation described in section 4.1.
- Documentation of modifications in the source code or modifications of the parameters. The documentation of the modifications must be easy to understand and the modifications must have been approved. This can be achieved by the description of the version management. When parameters are modified, test data sets must be provided which prove that the modified parameters lead to plausible calculation results.
- In addition, a detailed list of competent contact persons must be available.
- Security measures against maloperation and manipulation must be described.
- Error detection must be described.
- The calculation of the check sums must be explained and the necessary information for examination of the check sums (keys) be given.
- Data storage must be described.
- The complete set of instructions and parameters and the data format of the input values which can be received via an interface must be described. The impact of each instruction must be explained. In addition, the provider

(manufacturer) must declare in writing that the list is complete and that the instructions which have not been mentioned will not affect the dose calculation.

5   Procedure in the case of software modifications

After the approval, only the tested version may be used for dose determination. Without the knowledge of the supervising authority, the approved calculation programs must in no way be changed. Any change (e.g.: modification or error removal) must be reported to the relevant authority and a supplement to the approval is to be applied for. Changes of the parameter data (see 3.2.1) also require prior approval or re-examination.