A new evaluation of the cases of internal contamination with $^{241}\text{Am}$ from the year 2001.

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Introduction.

Widespread contamination occurred in the building in which radiation waste was handled. An occurrence of internal contamination of workers was also suspected. Therefore, workers were measured in vivo and bioassay was performed too. Estimation of committed effective dose had to be based on results of excretion analysis as irremovable surface contamination occurred on the skin and hair of workers, thus influencing results of in vivo measurements. The results of bioassay of 7 workers were presented already before together with the evaluation of intakes and committed effective doses [1]. At present time, the cases were re-evaluated using IMBA Professional Plus software.

The main difference – in comparison with the previous evaluation are:

- the data sets with the excreted activity with urine and faeces are used simultaneously
- the logarithmic – normal distribution of the data is assumed
- uncertainty of the measured data is chosen according to IDEAS Guidelines
- combination of acute and chronic intakes is used
- aerosol absorption class in the lungs M and S [2] and parameters for absorption found experimentally

Procedures used for evaluation of the data.

Software IMBA enables to use different data sets simultaneously. The realistic choice of the uncertainty of the measured values has a basic importance for the evaluation. The uncertainty has to include counting errors, uncertainty of the method, biological variation and uncertainty of the collection of samples. Counting errors are generally very small (up to 4%); what is enabled by the use of long counting times. Uncertainty of the method could be estimated not greater than 10%. However, biological variation and uncertainty of the sampling are significant. In the Guidelines from IDEAS EU project [3] it was estimated on the base of literature and on the experience of participating scientists that for the activity in the urine under the assumption of logarithmic – normal distribution, uncertainty is given by a factor of 1.3 and for the faeces by a factor 3 to 5. This factors could be used in cases when good sampling discipline exist. Therefore, in some real americium cases, the factor of uncertainty for the urine was increased to 1.7 and 1.8 and for faeces, factor 5 was used.

Results and discussion.

Experimentally obtained results of excreted activity of $^{241}\text{Am}$ with urine and faces were fitted by model excretion curves; in this process, different parameters were used. The time of the intake was chosen according to work diaries, and according to the investigation made after the incident. As this times were not given unequivocally, different times were chosen and than for further calculation used such for which visual agreement with the measured data was satisfactory. Generally, workers could be contaminated between 10 July and 21 July, than went to hospital for infusion of DTPA and after the stay in the hospital went on holidays and didn’t return to the workplace until mid-August 2001 [4]. Therefore, the time interval 20 - 60 days was supposed as the time in which intake of $^{241}\text{Am}$ didn’t occur. Afterwards, the chronic intake was assumed.

According to analysis of samples from workplace, it was probable, that the aerosol has longer half – time of dissolution in the lungs than the one for the class M [5]. Therefore, combination of aerosol
of the class M and S was used; also half – time found in experiment with dissolution of aerosol in simulated lung liquid was used in some cases.

The best fits for the most of workers were obtained when combination of acute and chronic intakes was used. Only in one case (P.V.), only single intake gave relatively good fit, in one case (F.H see fig.1) combination of a one acute intake and three chronic intakes was used. For the illustration two other cases (V.V and M.S) are presented in the fig. 2 and 3.

Acute intakes varied from 146 Bq to 691 Bq, chronic intakes continuing up to 600 days after the first intake varied from 0.03 Bq/d to 0.5 Bq/d. There are two cases with chronic intakes 4 days and 20 days with the intakes 28 Bq/d and 39.5 Bq/d. Resulting committed effective doses from 4.3 mSv to 35 mSv were estimated for individual workers. In the table 1, results for 6 workers are presented. For worker F.H., the best agreement between the experimental data and model curves were obtained for 3 intake in the time 0 (18.7.2001), chronic from 30. to 50. day and another chronic from 60. to 560. day – resulting in the intakes 321 Bq (class S), 39.5 Bq/d with the absorption rate $1.38 \cdot 10^{-3}$, and 1.8 Bq/d (class S); committed effective dose was estimated to be 34.6 mSv.

![Graph of F.H. urine and Faeces](image)

Figure 1. Worker FH, experimental values of excreted activity through urine and faeces fitted by model curves. Red points (first 5 points in urine measurement) were not used for the fitting as the excretion rate was influenced by administration of DTPA.
The values of the intakes and committed effective doses in the table 1 differ from the ones which were published in [1], however, the differences in committed effective doses are in most cases small. For both evaluation, IMBA software was used, but only in later time, it was possible to use IMBA with statistical packet. In [1] only class M and S were used for the characterization of aerosol solubility in the lungs; at present time, also parameters from the experiment with the solubility of aerosol from air filters in a solution, simulating lung fluids [4] were used.

Table 1. Estimation of the intake of $^{241}$Am and committed affective doses E(50).

<table>
<thead>
<tr>
<th>Worker</th>
<th>1st intake Date of intake</th>
<th>Aerosol, class</th>
<th>2nd intake class</th>
<th>E (50) [mSv]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS</td>
<td>9.7.2001</td>
<td>$S \approx 1.38 \times 10^3$</td>
<td>691 Bq</td>
<td>60 - 560 S</td>
</tr>
<tr>
<td>PV</td>
<td>9.7.2001</td>
<td>S</td>
<td>159 Bq</td>
<td>-</td>
</tr>
<tr>
<td>VV</td>
<td>10.7.2001-20.7.2001</td>
<td>S</td>
<td>179 Bq/d</td>
<td>40 - 600 M</td>
</tr>
<tr>
<td>KH</td>
<td>12.7.2001-18.7.2001</td>
<td>M</td>
<td>207 Bq/d</td>
<td>40 - 560 M</td>
</tr>
<tr>
<td>VS</td>
<td>15.7.2001</td>
<td>S</td>
<td>348 Bq</td>
<td>0 - 4</td>
</tr>
<tr>
<td>LZ</td>
<td>18.7.2001</td>
<td>M</td>
<td>564 Bq</td>
<td>30 - 120 S</td>
</tr>
</tbody>
</table>

Fig.2 Worker VV, experimental values of excreted activity through urine and faeces fitted by model curves. No DTPA was applied in this case.
Fig. 3: Worker MS, experimental values of excreted activity through urine and faeces. Fitted by model curves. Red points (4th to 9th) were not used for the fitting as the excretion rate was influenced by administration of DTPA.

Conclusions.

Estimation of the intakes and committed effective doses were stepwise improved as more informations from workplace were gained. Use of the sophisticated software IMBA, enabling simultaneous use of more data sets and enabling change of different input parameters made a significant improvement in the evaluation of experimental data. However, with exception of one case, the statistics of the fit was not good enough. Variation of more parameters in the model of americium biokinetics could be next step. However, it is not expected that it will lead to significant changes in the estimation of the doses.

References
3. IDEAS Guidelines: http://www.ideas-workshop.de/