Mechanism of interpretation of seized materials without creation of nuclear forensics library

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Abstract. Approach to interpretation of unknown nuclear or other radioactive materials by using national nuclear forensics libraries is characterized by a set of inherent deficiencies. These deficiencies force to use other approaches to interpretation of seized unknown nuclear or other radioactive materials. Alternative approach is considered. It is based on the results of experienced experts' estimations and analyses of measured characteristics of seized material or its trace amounts as well as on the subsequent implementation of comparative investigation of both: seized and suspected materials at the same time in nuclear forensic laboratories.

1. Introduction

Interpretation of seized nuclear or other radioactive materials, determination of its origin and possible designation are the essential parts of any investigation, which is associated with illicit trafficking of such materials. This investigation includes comparison of characteristics of the seized material or the detected trace amounts of unknown material, which are determined in the result of its analysis, with the data about known materials.

IAEA nuclear security publication [1] recommends establishing national nuclear forensics libraries (NNFL) for inventory of nuclear and other radioactive material. These libraries should include databases of all material produced, used and stored in the State, and considered by several experts as a tool for nuclear forensics data interpretation. Another IAEA publication [2] requests States to consider establishing a programme that compiles libraries of inventoried/registered nuclear and other radioactive material as one of main elements of the national nuclear security infrastructure. Furthermore, IAEA is developing a special nuclear security guidance document on nuclear forensics libraries [3], where the role of such libraries in interpretation of seized material data seems overestimated.

2. Interpretation of seized material like one of the main elements of incident investigation

Interpretation of nuclear and other radioactive materials, determination of its origins, deterrence of potential criminals, facilitating to development of international cooperation in the nuclear forensic field are mentioned and listed like the tasks, which can be solved by using NNFL. At the same time possibility of solution of these tasks without creation of NNFL is hushed.

But it should be noted that deterrence of potential criminals is determined only by inevitability of solving the crime. Consequently for such deterrence only the possibility of right interpretation and attribution of seized material is important. And it does not matter how this possibility is provided. May be NNFL can facilitate to right interpretation and attribution, may be right interpretation and attribution can be implemented without NNFL. For example, right interpretation and attribution can be implemented by using the databases, which are not combined in NNFL, or by using comparative analyses of seized material and reference materials from materials archive.

Living aside political component of the issue, international cooperation is organized for the best investigation of the incidents and crime solution. It is also directed on the right interpretation and attribution of seized material. So, only one NNFL's task is really important for investigations practice – facilitating to right interpretation and attribution of seized materials. At the same time it is necessary to note that NNFL is defined, as "an administratively organized collection of information on nuclear and other radioactive materials produced, used, or stored within a State that may come from different and diverse sources" [3]. It means that NNFL is administratively organized collection of databases. Therefore working instruments of NNFL are databases. Nevertheless right interpretation and attribution of seized material depends on quality of databases, but not of their inclusion in NNFL.

3. Deficiencies of databases and NNFLs for investigation goals

All other structural parts of NNFL, which should be created above databases, are not important for the conclusion about the origin of seized materials. Therefore the interpretation of seized unknown nuclear or other radioactive materials by using NNFL or by using scattered, not organized in NNFL, databases contain the same inherent deficiencies:

- Comparison of the results of analysis of seized material or trace amount of material with information from data bases. Obviously such comparison allows to withdraw from the suspicion a lot of materials, characteristics of which are very different from characteristics of seized material.
  But it is known that several similar materials can be manufactured at different facilities or produced by fuel irradiation in different reactors. Investigation of incidents with such materials is most complex for prosecution. On the other hand analyses of the same material in different laboratories can provide not the same results. Moreover, analyses of the same material in the same laboratory, but in different times and/or by using different techniques can sometimes provide not the same results also. But comparison of the result of analysis of the seized material and suspected materials implies the comparison of the results, which are obtained likely in different laboratories and obviously at different times. Therefore material cannot be undoubtedly attributed on the result of such comparison.
- List of characteristics, which should be measured for undoubted interpretation of nuclear or other radioactive materials, is not determined until now. Moreover it is very likely that different lists will be required for investigation of different incidents. Characteristics, which will be really necessary for nuclear forensics investigation goals, can be determined after first steps of the investigation. It is clear [4] also, that databases, which are created for technological control, only contain at best a small part of forensically significant information. On the other hand there is considered for instance the possibility of measuring of the contents of a lot of chemical elements (up to 64) for identification of UOC [5]. Therefore, creation of comprehensive database is very labour and resource intensive process. Due to the low frequency of nuclear security events such a creation may be unreasonable;
- The concept of national nuclear forensics libraries, presented in [3], reflects simplified understanding of forensic database. "Forensic database" not only means that it is used during criminal investigation. A set of specific requirements is inherent to forensic database. First requirement is periodic actualization of database for the whole range of materials, which are currently manufactured. Secondly, database should contain information about intermediate products of manufacturing, etc.

One more deficiency concerns the NNFLs, but does not concern scattered databases. Accumulation of a lot of information, including sensitive information, in additional point of storage enlarges the circle of knowledgeable people and increases the risk of unauthorized sharing of information.

These disadvantages of any databases as well as NNFLs for prosecution goals force to use other approaches to interpretation of seized unknown nuclear or other radioactive materials.

4. Another approach – involvement of experts and comparative analyses

As indicated in IAEA nuclear security publication [6], “nuclear forensics does not consist of routine procedures that can be universally applied to all evidence”. Direction and scope of each subsequent step of nuclear forensics analysis should be selected in accordance with the results of previous steps. Another interpretation mechanism based on the involvement of experienced experts to estimation of measured characteristics of seized materials or its trace amounts as well as to subsequent implementation of comparative investigation of both: seized and suspected materials at the same time in the same analytical laboratory (laboratories). Several nuclear forensic laboratories can be involved firstly for supporting the conclusions of one laboratory and secondly for measuring entire set of requested characteristics if all of them can not be measured satisfactory in one laboratory.

Involved experts should have knowledge and experience of handling with materials of corresponding type. Range of experts can be determined after first identification of seized material or its trace amounts. Experts will be able to determine the group of materials, which can be suspected as the origin for seized material. They will be able also to choose materials for comparative investigations, to assess the significance of differences in measured characteristics of seized and suspected materials. By the way scattered material databases or any information of NNFL can be useful for choice of suspected materials for comparative analyses. Samples of these materials can be requested from corresponding material archive.

Only coincidence of all measured characteristics in seized material and in one or in several suspected materials provide the prosecution with undoubted conclusion about origin of seized material (possible origins in the case of coincidence of characteristics of seized material and several suspected materials).

If requested sample is absent in material archive and it is impossible to find corresponding sample anywhere, experts are forced to use any information about such materials, including information from all suitable databases. In these cases expert evaluation should be based on the knowledge of the details of manufacturing technologies, operational features, knowledge of the sources of raw materials for different manufacturing, etc. But expert evaluation should contain additional expertise of real and all possible differences of the results of measurement as well as all possible variations and uncertainties of the published data.

Such approach is realized, for example, in Russian Federation. Russian Federation has a large range of nuclear and radioactive materials and owns a lot of technological databases, which are not concentrated on one site. This approach focuses on the Russian legislation and does not require additional management and centralization.

5. “Galaxy serpent” exercises – confirmation of necessity of expert involvement

The virtual table top exercise “Galaxy serpent” held in 2013 confirmed that assessment of the significance of differences between the results of analysis and information from database can require involvement of experts even if the comprehensive database is accessible [7]. “Laboratory for Microparticle analysis” participated in the final round of this exercise in February-March 2014. Conclusion had to be elaborated about the possible pertaining of the “seized material” to the spent fuel of one from three reactors on the result of comparison of “the results of analysis of the seized material” and the data about spent fuels of reactors. Comparison had to be implemented on the set of spent fuel parameters.

On the result of comparison two reactors were qualified like reactors, which can not be the origin of “seized material”. Spent fuel of one of them is characterized by concentration of uranium-235 of 2.04% at the burn-up of 5.88 GWD/MTU, while that concentration in “seized material” is significantly higher, 2.37%, even at the larger value of burn-up – 6.41 GWD/MTU. Spent fuel of another reactor is characterized by concentration of uranium-235 of 1.26% at the burn-up of 16.00 GWD/MTU, while that concentration in “seized material” is significantly higher, 1.65%, at the larger burn-up of 18.08 GWD/MTU. Uncertainties of the measurements do not compensate the differences in concentrations.

At the same time comparison of “the results of analysis of the seized material” with available characteristics of the third reactor could not identify significant differences for “seized material” and spent fuel of the third reactor. This spent fuel should be considered like possible origin of the “seized material”. Nevertheless definite conclusion can not be stated that this spent fuel is the origin for “seized material” because any database con not be overall. And it can not be guaranteed that there is no another reactor, spent fuel of which is characterized by the same parameters at some burn-ups.

For example, concentrations of uranium-235, uranium-236 and plutonium for reactors of different typs are presented on the fig.1 [8]. Only initial enrichments are almost the same.

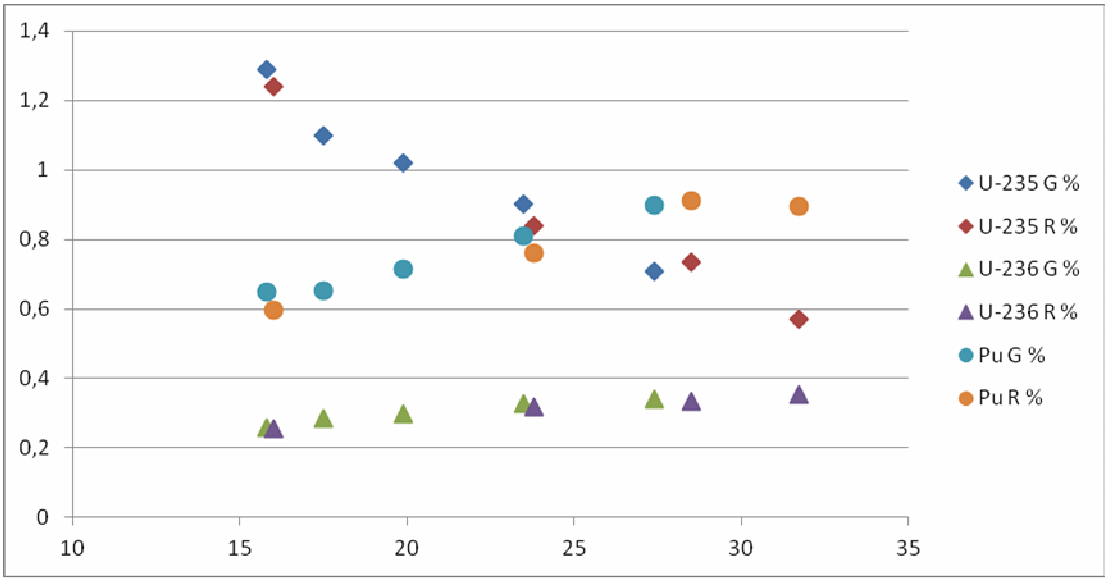

FIG. 1. Concentrations of plutonium and isotopes of uranium in spent fuel (%) of reactors BWR Gundremmingen (G)and PWR Robinson (R) at different burn-ups (GWD/MTU).

One of them is installed in Germany, another – in USA. It can be seen that isotopic composition of spent fuel depends on burn-up rather then on the power reactor parameters.

So, “Galaxy serpent” held in 2014 confirms again that databases can be successfully used for exclusion of some materials from the list of suspicious ones, but for attribution of material they are not sufficient. Of course this conclusion is true for both: scattered databases as well as databases, which are associated with NNFLs.

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