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UMEX Project, an IAEA Survey of Global Uranium Mining and Processing Occupational Doses

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INTRODUCTION

With the current level of interest in nuclear power, there has been an increase in uranium exploration and in the development of new uranium production facilities in many countries [1]. Such facilities include in situ leaching operations and facilities for the mining and processing of uranium ore. Workers engaged in uranium production receive external exposure to gamma radiation emitted from uranium ore, process materials, uranium products, tailings and other process residues. In addition, they receive internal exposure from the inhalation of airborne dust particles containing long-lived alpha activity and from the inhalation of radon and its short-lived decay progeny [2, 3]. The number of uranium production workers may increase substantially over the next few years.

Against this background, the IAEA has established the Uranium Mining Exposure (UMEX) project. The general aim of the project is to strengthen and enhance the radiation protection of uranium production workers, while more specific aims are to increase the opportunities for optimization of protection and to support quality assurance programmes across the industry. Within the framework of the project, the following key activities have been initiated with respect to uranium production workers worldwide:

(a) Development of an information system for occupational exposure;
(b) Evaluation of the current occupational radiation protection situation;
(c) Identification of instances of good practice, opportunities for improvement and, where appropriate, actions to be implemented for assisting employers, workers, regulatory bodies and other stakeholders in implementing the principle of optimization of protection and safety.

In 2012, the IAEA developed a questionnaire which was distributed to uranium producing countries. In 2013, responses to the questionnaire were received from 36 operating facilities which, between them, accounted for about 85% of worldwide uranium production. This paper presents:

(a) The results of the information survey and a preliminary analysis thereof;
(b) A summary of current practices for monitoring and reporting of occupational exposure;
(c) A summary of occupational exposures reported for 2012.

ANALYSIS OF RESULTS

Total annual effective dose

(a) For mining and processing facilities at sites using underground extraction, the overall dose was heavily influenced by one operator owing to the large number of occupationally exposed workers recorded for this particular facility.

(b) Among the mining and processing facilities at sites using opencast extraction, two operators had by far the highest numbers of occupationally exposed workers and therefore had a major influence on the overall dose.

(c) For facilities using in situ recovery, one operator had the highest number of occupationally exposed workers but, because this was an amalgamation of 15 facilities which were treated separately in the weighted averaging process, the overall dose was not unduly influenced and was therefore considered representative of in situ recovery facilities in general.

Contributions from the three exposure pathways

(a) In underground mines, the contributions from external gamma exposure and internal exposure to inhaled short-lived radon decay progeny were similar (47% and 43%, respectively), while the contribution from the inhalation of long-lived radionuclides in airborne dust was much smaller (10%). This reflects the approach taken in modern underground mines, namely, a combination of dust suppression, good ventilation and shielding against gamma radiation.

(b) In the processing of ore derived from underground mining, the contributions from external gamma exposure and internal exposure to inhaled long-lived radionuclides in airborne dust were similar (44% and 34%, respectively), while the contribution from internal exposure to inhaled short-lived radon decay progeny was smaller but still significant (22%). However, since background subtraction was not generally used for exposure to radon decay progeny, a significant proportion of this contribution may not have been related to the ore processing operation.

(c) In opencast mining operations, the main contribution was from external gamma exposure, as would be expected for modern mining methods. Gamma shielding is not generally possible beyond that provided by the heavy earthmoving equipment that many workers operate. The next most significant contribution was that from the inhalation of long-lived radionuclides in airborne dust —this was dominated by some operators which were both in semi-arid regions where airborne dust was likely to be more prevalent because of less water being available for dust suppression and more rapid drying of material. The inhalation of short-lived radon decay progeny was the least significant exposure pathway, as would be expected given the natural dispersal of radon within large open pits.

(d) In the processing of ore derived from opencast mining, the relative contributions to the total dose were, as expected, similar to those in facilities processing ore from underground mining.

(e) In operations involving in situ recovery, the main contributor to the total dose was external exposure to gamma radiation. It should be noted, however, that this result is almost totally related to one operator which is an amalgamation of 15 separate facilities, none of which applied a correction for background gamma radiation, leading to the likelihood of a significant overestimation of occupational exposure from this pathway.

(f) Facilities categorized as 'other'included facilities for uranium recovery from rehabilitation, waste water treatment and a form of contract processing known as 'toll milling'. The relative contributions from the three exposure pathways varied widely. One of the operator provided only gamma exposure data and this pathway was therefore recorded as the only contributor to the total dose. In the case of one operator , a contract processing operation which had the largest number of occupationally exposed workers, external gamma exposure was the largest contributor to the total dose —this was expected given the nature of a purely contract processing operation.

MAIN OBSERVATIONS AND CONCLUSIONS

A worldwide survey of occupational radiation exposure in the production of uranium was performed in 2013. Responses were received from 36 operating facilities covering nearly 85% of global uranium production. A review of information from the responses to the UMEX questionnaire has identified several observations of a general nature as well as more specific observations on assessments related to individual exposure pathways.

These are summarized as follows:
(a) General observations:
(i) Although several methods have been adopted for the production of uranium, the most widely used method is in situ leaching, followed by underground and opencast mining of uranium ore;
(ii) The most widely used technique for the processing of uranium ore is acid leaching, followed by alkaline leaching;

(b) Assessment of external exposure to gamma radiation:
(i) Most facilities use TLD methods for the assessment of individual doses;
(ii) The most widely used assessment strategy is the monitoring of all occupationally exposed workers, followed by the monitoring of average exposures of selected groups and the monitoring of selected individuals;
(iii) Approximately 50% of facilities do not use background subtraction, leading to an overestimation of the doses received by workers;

(c) Assessment of internal exposure from the inhalation of long-lived radionuclides in airborne dust:
(i) Approximately 50% of facilities use workplace dust sampling and 50% use personal dust sampling;
(ii) Most facilities use gross alpha counting methods for assessing the alpha activity in dust samples;
(iii) Most facilities use periodic monitoring for the assessment of exposure;
(iv) Most facilities do not routinely use bioassay monitoring techniques, although some facilities are using urine analysis;

(d) Assessment of internal exposure from the inhalation of short-lived radon decay progeny:
(i) The most widely used monitoring technique is active workplace monitoring of radon progeny in conjunction with the use of timesheets, followed by active monitoring of radon progeny using personal dosimeters;
(ii) The most widely used monitoring strategy is work group averaging, followed by individual monitoring;
(iii) Most facilities do not use background subtraction, which may lead to some overestimation of the dose;

(e) Dose assessment:
(i) The most widely used method for the determination of occupancy time is the timesheet method, followed by the use electronic devices;
(ii) While various dose conversion factors are being used, most facilities use factors specified by the regulatory body or by international recommendations or standards;
(iii) There is a need for global harmonization with respect to the selection of dose conversion factors in order to provide a common basis for comparison;
(iv) In order to obtain a more reliable estimate of the dose from inhalation of radionuclides in airborne dust, parameters such as particle size, solubility and radionuclide composition should be included in the dose calculation.

Overall findings showed an industry in compliance with international standards on radiation protection and a strong commitment to optimisation of protection. A new survey has been proposed and will be introduced.

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Country or International Organization

International Atomic Energy Agency

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