AN INTERNATIONAL CO-ORDINATED RESEARCH PROGRAMME ON NUCLEAR ACCIDENT DOSIMETRY

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1. INTRODUCTION

Where fissile materials are being processed in quantities exceeding the minimum critical amounts, a radiation risk to workers would arise from the possibility of criticality excursions. Techniques and procedures for preventing the occurence of such accidental excursions have reached very high standards. This is very well reflected in the exceedingly small number of criticality accidents which have been reported so far. 35 criticality accidents have been documented since 1944. Only one criticality accident has been reported during the last 10 years, a period within which the world's inventory of fissile materials has been substantially increasing. Despite this very laudable safety record it is generally agreed that specially designed criticality dosimetry systems should continue to be available to provide, in case of an accident, information on personal neutron and gamma ray exposure within required accuracies at required times for the guidance of the medical services in appropriate medical treatment of more heavily exposed personnel and for reassuring personnel who have only been slightly exposed.

2. IMPLEMENTATION OF PROGRAMME

In February 1969 the IAEA convened a panel of dosimetry experts to review the experience gained in assessing doses to persons exposed to nuclear radiations in criticality accidents (1). Following the recommendations of this panel the IAEA, subsequently, established an international co-ordinated research programme on nuclear accident dosimetry with the aim of improving the performance of existing nuclear accident dosimetry systems and elaborating standardized systems that would perform within criteria laid down by this panel. The opinion of the experts was that an adequate system should provide data to enable an initial determination of the maximum absorbed dose in the body within 48 hours with an uncertainty of less than 50% of its neutron and gamma components separately, and, if initial determination yields dose estimates greater than 0.25 Gy (25 rad) to a significant portion of the body, to enable an estimate within four days with an uncertainty of less than 25%.

A number of research contracts and research agreements, supporting theoretical studies as well as experimental work in the subject area, were concluded with laboratories in 13 Member States (Bulgaria, Canada, Czechoslovakia, France, Federal Republic of Germany, Hungary, India, Japan, Poland, UK, USA, USSR, Yugoslavia).
Research Co-ordination meetings were organized in order to facilitate exchange of ideas and to avoid undesirable duplication of work.

3. INTERCOMPARISON STUDIES

In addition to the regular research co-ordination meetings, international multilaboratory intercomparison experiments were organized for testing and calibrating existing criticality dosimetry systems in different neutron spectra under simulated accident conditions. Since 1970 four intercomparison experiments were held, at Valduc (France) in 1970, at Oak Ridge (USA) in 1971, at Vinca (Yugoslavia) in 1973 and at Harwell (UK) in 1975. In addition to research groups from 13 Member States listed earlier, experts from Italy and Denmark also participated in the experiments. Some information on these experiments is summarized in Table 1.

Experiment:	I	II	III	IV
Year:	1970	1971	1973	1975
Location:	Valduc (France)	Oak Ridge (USA)	Vinca (Yugoslavia)	Harwell (UK)
Facility:	C.R.A.C.	HPRR	RB 2	Viper
Neutron Spectrum:	well moderated	unmoderated	heavy moderated	well moderated with broad peak from 1 keV to 1 MeV
Number of different radiation fields utilized	2	3	1	1
Number of criticality excursions:	2	4	2	2
Number of participating research groups:	13	17	19	17
Number of participating Member States:	10	12	13	12

TABLE 1 IAEA International Intercomparison Experiments on Nuclear Criticality Accident Dosimetry during the period 1970 - 1975.

A great variety of dosimeters for personnel and area dosimetry were exposed in these experiments to seven qualitatively different mixed neutron - gamma radiation fields. In total ten criticality excursions of the order of 10^{17} - 10^{18} fissions were provided for examining the response of the dosimetry systems. The neutron- and gamma doses generated ranged from 0.1 Gy - 5 Gy (10 rad to 500 rad). Personnel dosimeters were exposed in free air as well as mounted on phantoms. Orientational studies, taking into account the direction of the incident radiation, were made. Sodium activity measurements in phantom parts were also carried out. Participants were requested to produce first data within 48 hours of each of the pulses. Later final data had to be given including information on number of activated atoms per 10^{10} atoms, on neutron fluence in defined energy intervals and on neutron and gamma doses. Detailed information on the components of the dosimetry systems employed, the measurement and evaluation procedures used and the results obtained at the four intercomparison studies is reported in Refs.(2,3,4,5,6). The last intercomparison experiment at the Viper facility in the UK with its high intensity component in the intermediate neutron energy region provided a most stringent test for the dosimetry systems employed. There were no significant differences between the mean results obtained by the participants within 48 hours of the pulse and after full evaluation. However, a significant reduction in the variation of the results between participants was observed, resulting in a reduction of the final standard deviation. Variations in the final mean were up to 20% for neutron dose and up to 25% for gamma dose for all participants(5). The results demonstrate that several systems are available now in a number of laboratories throughout the world that perform within the criteria laid down by the initiating panel in 1969.

4. RESULTS

The work carried out under this co-ordinated research programme by the contractors in the 13 Member States is reported in about 100 papers published in the open literature. These publications reflect the improvement of nuclear accident dosimetry systems since 1969. A number of interesting general points emerged from the intercomparison studies. Only two more important ones are addressed below:

i) The simpler the measuring system is, the more subsequent complex analysis is required. Many of the nuclear accident dosimetry systems that were developed over the last ten years are still evolving and there is still a diversity of opinion on the optimum method. However, in order to assist Member States and particularly developing countries in adopting a criticality accident dosimetry system for the first time, a comprehensive technical manual on nuclear accident dosimetry is being prepared by the IAEA with the help of experts from among the participants in this programme. The description of a minimal acceptable nuclear accident dosimetry system will be part of this manual (7).

ii) In a criticality accident, dose estimates to the required accuracy can only be obtained with existing systems if a reasonable approximation to the actual neutron spectrum involved is readily available. As an aid for dose evaluations, a compendium of neutron leakage spectra has been compiled, encompassing the most likely neutron spectra encountered in criticality accidents. 64 different neutron spectra, presented in tabulated form as well as graphically, are included in the compendium. Together with each set of spectral information average cross sections for a number of common detectors are also given to facilitate the application of spectral data to dosimetry. It is planned to publish the compendium under the IAEA Technical Reports Series in the near future(8).

In conclusion it can be said that the co-ordinated research programme provided a most efficient means for harmonizing multinational efforts and solving scientific problems in the subject area. The great advantage of the international intercomparison experiments for the participating experts was not only the opportunity to compare a variety of individual methods under simulated accident conditions but also the opportunity of access to facilities in different Member States providing unique radiation fields for calibrating nuclear accident dosimetry systems.

5. REFERENCES

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