OECD/NEA WORKING PARTY ON NUCLEAR CRITICALITY SAFETY: CHALLENGE OF NEW REALITIES

Y. Nomura (1), M.C. Brady (2), J.B. Briggs(3), E. Sartori (4)

(1) Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki-ken, 319-11, Japan
(2) DE&S Hanford Inc., Richland, WA 99352-0350, USA
(3) Idaho National Engineering & Environmental Laboratory, Idaho Falls, ID 83415-3890, USA
(4) OECD/NEA Data Bank, Le Seine-Saint Germain, F-92130, Issy-les-Moulineaux, France

SUMMARY

New issues in criticality safety continue to emerge as spent fuel storage facilities reach the saturation point, fuel enrichments and burn-ups increase and new types of plutonium-carrying fuels are being developed. The new challenges related to the manipulation, transportation and storage of fuel demand further work to improve models predicting behaviour through new experiments, especially where there is a lack of data in the present databases.

This article summarises the activities of the OECD/NEA working groups that co-ordinate and carry out work in the domain of criticality safety. Particular attention is devoted to establishing sound databases required in this area and to addressing issues of high relevance such as burn-up credit. This is aimed toward improving safety and identifying economic solutions to issues concerning the back end of the fuel cycle.

INTRODUCTION

Nuclear Criticality Safety was established as a discipline more than 50 years ago in response to several accidents that had occurred in nuclear weapons programmes. The number of documented criticality accidents in "western" facilities over this period is slightly less than 50. Information has only recently been disclosed concerning accidents which occurred in the ex-Soviet Union.

The importance of the safe handling of all fissile materials was recognised at an early stage both by the scientific community and the responsible authorities. At the beginning, intensive experimentation with a large variety of configurations and materials took place in order to establish a basis of knowledge for such systems. Computational methods and basic nuclear data, however, had either not yet properly developed or had not reached sufficient sophistication to reliably predict the critical status of fissile materials.

Over the years, substantial progress has been made in developing nuclear data and computer codes to evaluate criticality safety for nuclear fuel handling. This state-of-the-art knowledge also has an economic impact. The reduction of uncertainties in safety margins allows rational and more economical designs for manipulation, storage and transportation of fissile materials.

There are several working groups active in the Organisation for Economic Co-operation and Development's Nuclear Energy Agency (OECD/NEA) which seek to promote international understanding. A working party was recently organised to review the activities of the existing working groups and to propose establishing task forces corresponding to new demands on methods development, experimental needs and international handbook data in the field of nuclear criticality safety.

This article describes how the existing working groups are achieving successful results through international co-operation. It also discusses what the newly established working party hopes to accomplish from a global viewpoint with regard to emerging problems in nuclear criticality safety.

INTERNATIONAL CRITICALITY SAFETY BENCHMARK EVALUATION PROJECT (ICSBEP)

The ICSBEP, chaired by Mr. J. Blair Briggs, INEL, USA, is one of the OECD/NEA working groups. It was initiated in 1992 by the US-DOE and became an official activity of the OECD/NEA in 1994. Its purpose is to provide the nuclear industry with qualified benchmark data-sets by collecting criticality experiment data from the US-DOE national laboratories, rigorously reviewing the information and making sure it is edited in a consistent format. International member countries include France, Hungary, Japan, Republic of Korea, Russia, and the United Kingdom. The fruit of this effort is a seven-volume benchmark data handbook; each volume represents different fissile material included in the experiment systems for use in validation of criticality safety computer codes as shown in Table 1 (J.B. Briggs ed., 1996). A third edition of this handbook has already been published, and it is also available on CD-ROM. This revised edition contains new data for about 1 500 critical configurations. The reviewing activity of the ICSBEP ensures that the handbook is continually revised through the addition of new experimental data.

CRITICALITY SAFETY BENCHMARK WORKING GROUP

The Criticality Working Group is another OECD/NEA organisation. Originally chaired by Dr. G.E. Whitesides, ORNL, USA, this group has examined the validity of computational methods in criticality safety evaluation relative to the storage, handling and transportation of fissile materials since 1980. Its current activity, chaired by Dr. Michaele C. Brady, DE&S, USA, is focused on an effort to establish the validity of computational methods applicable to the so-called burn-up credit design for spent fuel storage and transportation. The development of this method implies a very significant economic gain if one can take credit for the spent fuel nuclide composition. Currently, the results of studies on PWR fuel benchmark calculation contributed by many member countries – including Belgium, Czech Republic, France, Germany, Japan, Spain, Sweden, Switzerland, United Kingdom and USA – are almost complete. As a result, the group's focus is now shifting toward the analysis of BWR fuel benchmark results. These activities are summarised in Table 2 (M.C. Brady *et al.*, 1996).

Table 1. Distribution of Configurations in the Benchmark Data Handbook

Plutonium Metal Systems	32
Plutonium Compound Systems	0
Plutonium Solution Systems	19
Vol. 1, Total Plutonium Systems	**51**
Highly Enriched Uranium Metal Systems	31
Highly Enriched Uranium Compound Systems	9
Highly Enriched Uranium Solution Systems	25
Vol. 2, Total Highly Enriched Uranium Systems	**65**
Intermediate/Mixed Enrichment Uranium Metal Systems	8
Intermediate/Mixed Enrichment Uranium Compound Systems	1
Intermediate/Mixed Enrichment Uranium Solution Systems	1
Vol. 3, Total Intermediate/Mixed Enrichment Uranium Systems	**10**
Low Enriched Uranium Metal Systems	0
Low Enriched Uranium Compound Systems	23
Low Enriched Uranium Solution Systems	3
Vol. 4, Total Low Enriched Uranium Systems	**26**
U-233 Metal Systems	6
U-233 Compound Systems	0
U-233 Solution Systems	2
Vol. 5, Total U-233 Systems	**8**
Mixed Uranium-Plutonium Metal Systems	7
Mixed Uranium-Plutonium Compound Systems	4
Mixed Uranium-Plutonium Solution Systems	5
Vol. 6, Total Mixed Uranium-Plutonium Systems	**16**
Special Isotope Metal Systems	3
Special Isotope Compound Systems	0
Special Isotope Solution Systems	0
Vol. 7, Total Special Isotope Systems	**3**

Table 2. Summary of Benchmark Problems Addressed by OECD/NEA Criticality Safety Benchmark Group

Benchmark	Primary Objective	Status
Phase I-A	Examine effects of seven major actinides and 15 major fission products for an infinite array of PWR rods. Isotopic composition specified at 3.6 wt % U-235 at 0, 30 and 40 GWd/MTU and at one- and five-year cooled.	Completed
Phase I-B	Compare computed nuclide concentrations for depletion in a simple PWR pin-cell model, comparison to actual measurements at 3 burn-ups (27.34, 37.12 and 44.34 GWd/MTU).	Completed
Phase II-A	Examine effect of axially distributed burn-up in an array of PWR pins as a function of initial enrichment, burn-up and cooling time. Effects of fission products independently examined.	Completed
Phase II-B	Repeat study of Phase II-A in 3-D geometry representative of a conceptual burn-up credit transportation container. Isotopic compositions specified.	Completed
Phase II-C	Key sensitivities in criticality safety to burn-up profiles.	Proposed
Phase III-A	Investigate the effects of moderator void distribution in addition to burn-up profile, initial enrichment, burn-up and cooling time sensitivities for an array of BWR pins.	Preliminary Results Submitted
Phase III-B	Compare computed nuclide concentrations for depletion in a BWR pin-cell model.	Draft Specifications
Phase IV	Investigate burn-up credit for MOX spent fuel.	Proposed
Phase V	Investigate burn-up credit in sub-critical systems.	Draft Specifications

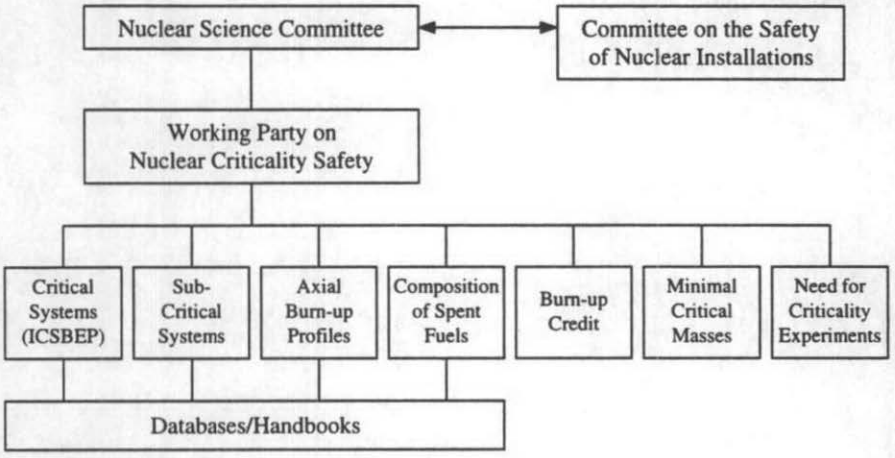
WORKING PARTY FOR NUCLEAR CRITICALITY SAFETY

Other activities are being considered in such related fields as needs for critical experiments, sub-criticality benchmark database, standardisation of criticality parameters, and criticality accident analysis. Activity has already commenced in some of these areas, while action regarding other topics is still in the planning stage.

During a recent expert meeting concerning needs for critical experiments, it was concluded that, in view of the limited number of operational critical facilities and the international scope of the needs for criticality safety technology, the NEA should encourage the performance of new critical measurements on a multilateral, international basis with regard to the sharing of facilities, staff expertise and funding resources. Also, given the absence of some experimental capabilities in many countries and the near unique capabilities in others, the NEA should, through its Member countries' representatives, recommend to their sponsoring agencies that certain facilities with unique capabilities be made available for international measurements programmes. This policy would reduce the need for redundancy in capabilities and promote stable funding for maintaining staff and equipment. With the expanding number and scope of NEA activities on criticality and safety, it was recommended that a Working Party for Nuclear Criticality Safety should be established to provide guidance and overall co-ordination for these activities.

Considering the above situation, a proposal to set up a new working party was discussed at the Criticality Working Group during the PHYSOR'96 Conference held in Mito, Japan in 1996. The necessity of such a working party was acknowledged at the NSC (Nuclear Science Committee) Bureau meeting in September 1996. The new group will attempt to review separate WG activities, find out needs to establish a new activity, and make recommendation to set up a new task force to NSC. The organisation and activities under the Working Party on Nuclear Criticality Safety is shown in Figure 1 (E. Sartori, 1997).

Figure 1. NEA/OECD Activities Under the Working Party on Nuclear Criticality Safety



CONCLUDING REMARKS

This timely reorganisation of OECD/NEA Working Party on Nuclear Criticality Safety will enable us to cope with new realities which have emerged in recent decades such as the escalation of back-end costs of the nuclear fuel cycle and the delay in commercialisation of fast reactors. Other issues resulting from the end of the Cold War, i.e. the necessity of criticality safety assessment applicable to unprecedented issues such as massive transportation and long-term storage of LWR spent fuel, MOX fuel fabrication and its transportation for use in LWR as a means of plutonium stockpile reduction, etc., also need to be addressed.

In the coming years there will likely be further clarification of potential nuclear fuel cycle strategies, each one with its specific needs in criticality safety. Although a wealth of information is available from more than 50 years of cumulative knowledge acquired, case-specific analyses will be needed and will dominate debate and research. Criticality safety calls for constant support and attention. A sound understanding and correct application of the principles of nuclear criticality safety are vital to the nuclear industry. The objective is to pursue an accident-free goal, while keeping in mind the repercussions that an avoidable criticality excursion could have. Current activities and future initiatives will obviously build upon past accomplishments. Events have shown that criticality safety is an international issue. It is therefore in the interest of all that information be widely shared and disseminated, notably through the NEA.

REFERENCES

J.B. Briggs, ed., *International Handbook of Evaluated Criticality Safety Benchmark Experiments*, NEA/NSC/DOC(95)03 Rev. 1, 1996.

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Risk Assessment