International Atomic Energy Agency

INDC(NDS)-39/L

INDC-415

INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

THE ROLE OF NEUTRON DATA MEASUREMENTS IN THE UTILIZATION OF LOW ENERGY ACCELERATORS

Trevor A. Byer
Nuclear Data Section, Division of Research and Laboratories

Vienna, May 1971

IAEA NUCLEAR DATA SECTION, KÄRNTNER RING 11, A-1010 VIENNA

PREFACE

This paper was presented at the IAEA Study Group Meeting on the Utilization of Low Energy Accelerators in Latin America, held in Rio de Janeiro (Brazil) from 15-19 March 1971.

The Role of Neutron Data Measurements in the Utilization of Low Energy Accelerators

Trevor A. Byer
Nuclear Data Section, Division of Research and Laboratories

1. INTRODUCTION

In seeking to outline the possible directions in which programmes designed to enhance the utilization of low energy accelerators in developing countries should take, one always encounters the fundamental question as to whether such programmes should be oriented primarily towards furthering certain technological and economic goals or whether these programmes should essentially aim at fulfilling certain scientific and educational objectives. Whilst not intending to open the Pandora's box which this question always gives rise to, in this paper we shall discuss the role of neutron data measurements in the utilization of low energy accelerators, whilst paying special attention to both the economic motivation which acts as the primary stimulant towards performing such measurements and to the role which the IAEA can play towards assisting in planning and performing some of these measurements. To be specific, neutron data is here defined as the measured or deduced microscopic cross-sections, related fission, capture and scattering parameters, resonance and reaction parameters which characterize the interactions of neutrons with nucleii.

2. JUSTIFICATION FOR NEUTRON DATA MEASUREMENT AND EVALUATION PROGRAMMES

To-day, most of the fundamental neutron data required for the development and competitive economic operation of thermal reactors may be considered as being fulfilled,however this situation is still far from being achieved for the case of fast reactors. The work of Greebler and co-workers [1], [2], [3], has attempted to quantify and translate into identifiable economic parameters the effects of uncertainties in neutron data on the fuel costs of fast power reactors. These authors have shown [1] that for a sodium-cooled fast reactor, whose design and safety margins have not been severely limited by requirements on the sodium void and Doppler reactivity effects, the combined uncertainties in neutron data produce about a 0.15 mill/Kwh uncertainty in the fuel cycle costs. Furthermore, by imposing stringent safety margins on fast reactor design, the combined uncertainties in neutron data produce about a 0.25 mill/Kwh uncertainty in the fuel cost. It should be noted that this latter uncertainty represents an operating fuel cost uncertainty of about $ 1 million per year for a 600 MWe fast reactor operating at an 80 % load factor. This figure of 0.25 mills/Kwh uncertainty in the projected fuel cycle cost may be viewed in relation to a fuel cycle cost advantage over competing reactor types of the order of 0.5 - 0.6 mills/Kwh, which as in the case of fast breeders, is considered to be sufficient motivation for the development of a new reactor type. The two main aspects of fast reactor design which are affected by uncertainties in neutron data are /1/ the plutonium credit and plutonium inventory components of the fuel cost and secondly the uncertainty in reactivity coefficients and other reactor performance characteristics related with data uncertainties.

The above remarks demonstrate the type of motivation which exists for performing neutron data measurements. Having translated this motivation into real economic terms, and therefore established its "unassailability", it is necessary to turn from the first question "why measure neutron data?" to the second question "what neutron data is needed and therefore what measurements should be performed?"

3. DEFINING THE NEUTRON DATA NEEDS

By identifying the type of neutron data that is needed and hence the measurements which should be performed to satisfy these needs, very immediate assistance is rendered to the experimentalist so that he may direct his skills and utilize his facility in obtaining results which are not only of the greatest interest, but also of the maximum usefulness and economic importance to national, regional or international nuclear programmes. One of the best internationally established mechanisms for revealing such needs is by means of the compilation and publication of 'Request Lists' in which those data which either do not presently exist or for which greater accuracy is desired are identified. One such 'Request List' is RENDA /4/ which is presently published under the auspices of the European American Nuclear Data Committee (EANDC).

The requests for neutron data measurements appearing in RENDA are primarily aimed at identifying the needs of reactor technology and in particular fast reactor technology. Each request is identified by the nuclide and physical quantity for which data is needed, the incident neutron energy range, the accuracy to which the data is required, the priority associated with the request and finally the requestor's name and motivation of the request. [4] The latest issue of RENDA [4] contains about 1300 such requests and a cursory examination of these requests will essentially reveal two groups of measurements which are needed - the first of which are difficult to perform and require highly sophisticated instrumentation and techniques in order to achieve the desired accuracy, and the second group of which should be readily within the capabilities of existing accelerator groups in Latin America. We shall therefore briefly mention this second group of needed data which includes:

A. U-238 Total cross-section to 8 % accuracy between 1-5 MeV, (n,2n) and total inelastic cross-section from threshold to 10 MeV.

B. Pu-239 Total cross-section to 10 % accuracy from 100 keV - 1 MeV, (n,2n) and total inelastic cross-sections from threshold to 10 MeV to 10 % and 25 % accuracy, respectively.

C. Pu-240, Pu-241. Total cross-sections to 10 % accuracy from 10 keV to 5 MeV.

D. Th-232 (n,2n) cross-section from threshold to 10 MeV.

E. Ta (n,γ) cross-section from 1 keV - 10 MeV to 10 % accuracy, needed for control rod material.

F. Fission Product Capture Cross-Sections in the resonance and fast neutron energy regions.

G. Ti-46, Ti-47 (n,p) cross-sections from threshold - 15 MeV to 10 % accuracy, for threshold detectors.

H. Be (n,2n) cross-sections to 10 % accuracy from threshold - 14 MeV.

This is clearly only a partial list and I would refer those who are interested to the document RENDA [4] for further details.

In addition to such a "Request List" which is primarily oriented to neutron data for fission reactor development, the Nuclear Data Section is presently compiling two other "Request Lists", one for nuclear data measurements required for thermonuclear reactors [5] and the other of which is at a very preliminary and exploratory stage, at present, dealing with the type of nuclear data which may be needed for the development of safeguards instruments and techniques [6]. I shall comment briefly on the data needed for thermonuclear reactor development in which considerable progress has been made in the past few years. The thermonuclear neutron energy range may be divided into two regions: from thermal to 5 MeV and from 5 to 14 MeV, of which only the latter will be discussed since most of the data in the first energy range overlap with the fission reactor needs. Between 5 to 14 MeV and in particular from 8 - 13 MeV there is a general dearth of neutron data. but this is an especially important energy region for thermonuclear work. In this energy region the materials and nuclear properties of special interest for fusion reactors are [5]:

I. Li-6 and Li-7 Total cross-sections, elastic and inelastic scattering cross-sections, the Li-6 and Li-7 (n, charged particle) cross sections, and the Li-6 and Li-7 (n,2n) cross-sections.

II. Nb and Mo. These are considered as possible materials for the vacuum chamber walls [5] and their total cross-sections are of importance. In addition, their elastic and inelastic cross-sections, as well as their (n,2n) and (n,p) cross-sections.

III. Pb, Be and Bi The (n,2n) cross-sections of these materials which would would be primarily needed to provide increased neutron multiplication.

These are just a few examples of the types of data that are needed and further reference should be made to the paper by Chernilin and Jankov /5_7 and the "Fusion Data Request List" to be published by Nuclear Data Section in the near future.

In the above examples, I have attempted to briefly outline the data needs for fission and fusion reactors and therefore the types of measurements which should be performed to satisfy these needs, in seeking to answer our second question "what neutron data is needed and therefore what measurements should be performed?" I now wish to turn to my third question, "how can the Agency assist you in performing some of these measurements?"

4. ASSISTANCE FROM THE IAEA

The Agency has two basic means of assisting and encouraging scientific and technological progress in the peaceful uses of atomic energy in Member States, namely the Technical Assistance Programme and the Research Contract Programme. These programmes which may provide assistance either in form of equipment, services of experts to assist in specific projects or direct financial support are well known and I shall therefore not discuss them further. The particular aspect of material assistance which I wish to mention is a new (but still unapproved) programme, whereby the Agency plans to assist developing countries in the acquisition of targets, samples and foils required to perform nuclear data measurements and, subject to approval, it is hoped that this programme can commence in 1972. Under this programme, each request for targets, samples or foils which is officially submitted (e.g. through the National Atomic Energy Commission) to the Agency, will be reviewed and assessed by the International Nuclear Data Committee (INDC) which acts as an advisory body to the Director General of the Agency on all matters pertaining to nuclear data. Since many targets and samples are not readily available in some developing countries, this programme, if approved, should help in alleviating the problems associated with the acquisition of these materials for data measurements.

To conclude, we would like to draw the attention of those of you who may be interested in performing the types of measurements illustrated above, that the Nuclear Data Section of the IAEA is in a position to supply any further information and advice regarding the planning and performance of these measurements.

References

/1_7 "Significance of Neutron Data to Fast Reactor Power Plant Design", by P. Greebler, B.A. Hutchins and B. Wolfe. 1968 Washington Conference on Neutron Cross-sections and Technology, Vol. 1, p. 291 (1968).

/2_7 "Calculated Nuclear Reactor Parameters and their Uncertainties in a 1000 MWe Fast Ceramic Reactor", by P. Greebler, C.L. Cowan, G.L. Gyorey, B.A. Hutchins, C.L. Fies and J.R. Sueska, GEAP-4471 (1966).

/3_7 "User Requirements for Cross-Sections in the Energy Range from 100 eV to 100 keV", by P. Greebler and B.A. Hutchins, GEAP-4472 (1966).

/4_7 RENDA - "Compilation of EANDC Requests for Neutron Data Measurements" - April 1970 - (Available from the IAEA Nuclear Data Section).

/5_7 "Nuclear Data for Thermonuclear Reactors", by Yu.F. Chernilin and G.B. Jankov, INDC(CCP)-10/U, (1970). Translated from IAE-1986.

/6_7 "Nuclear Data Requests for Safeguards Technical Development", INDC(NDS)-21/G, and Add. 1. and Add. 2. (Draft), compiled and edited by T.A. Byer.