



**EUROPEAN  
AMERICAN  
COMMITTEE ON  
REACTOR PHYSICS**

**EACRP-A-215**

**SUMMARY RECORD  
OF THE SIXTEENTH MEETING**

**CHICAGO, USA, JUNE 4-8, 1973**

*Compiled by*  
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- encouraging harmonisation of governments' regulatory policies and practices in the nuclear field, with particular reference to health and safety, radioactive waste management and nuclear third party liability and insurance;*
- forecasts of uranium resources, production and demand;*
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EUROPEAN AMERICAN COMMITTEE ON REACTOR PHYSICS

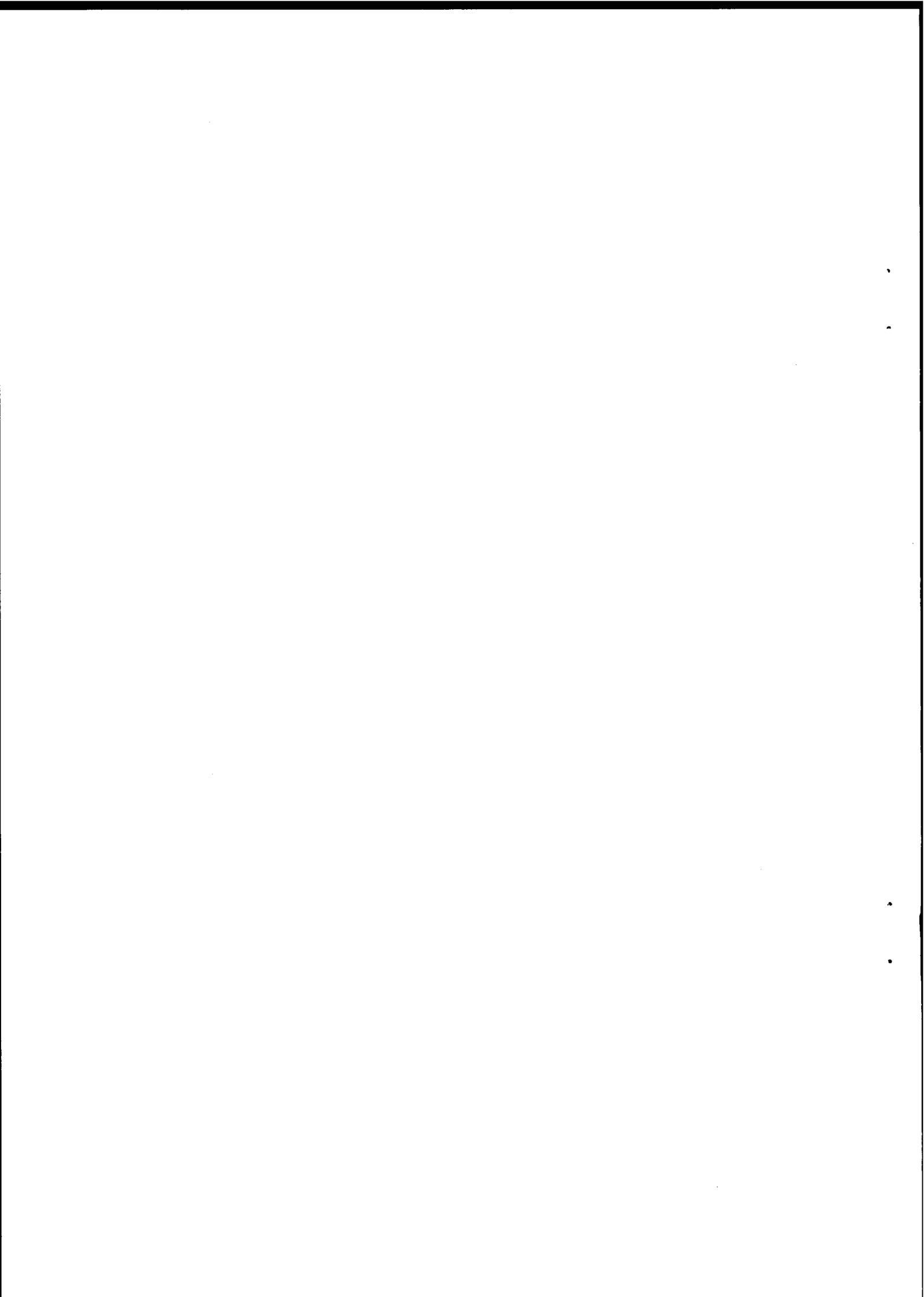
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SUMMARY RECORD OF THE SIXTEENTH MEETING

HELD IN

CHICAGO, USA, 3rd-6th June, 1973

PART A. COMMITTEE BUSINESS

1. GENERAL

1.1 Participants

New participating members: Dr. J. Bussac and Mr. B. Micheelsen representing France and Scandinavia, respectively.

Absent members: Dr. G. Casini, Ispra, Dr. R. Ortiz Fornaguera, Spain, Dr. R. Richmond, Switzerland and Dr. S. Kobayashi, Japan (cf. A 1.5).

NEA was represented by Dr. J. Royen. Dr. A. Smith and Dr. B. Spano participated as observers for EANDC and IAEA, respectively.

Although CREST had been invited to send an observer to the technical session, no-one from that committee attended the meeting.

The list of participants is given in Annex 1.

1.2 Adoption of the summary record of the fifteenth meeting

The summary record of the fifteenth meeting had been issued and distributed before the Chicago meeting. It was adopted without amendment.

1.3 Adoption of the agenda

The agenda was adopted in the form given in Annex 2.

1.4 Completion of actions

Annex 3 lists the actions agreed upon at the 15th meeting, and the actions taken.

The list of committee actions for the next meeting is given in Annex 4.

1.5 Committee representation

Royen reported that the Steering Committee of NEA had adopted the proposed new wording of the EACRP representation whereby Japan was entitled to two representatives on EACRP. He further said that

- the mandate for EACRP had been extended to 20th April, 1976;
- IAEA had again been informed by NEA that EACRP would welcome a Russian observer at its technical sessions.

Royen also proposed that with Japan having become a full member of NEA the name of the committee should be changed to the NEA Committee on Reactor Physics (NEACRP).

The committee members were asked let Royen have the reactions of their respective countries to the proposed new name.

As regards the representation of the different countries Bussac asked whether other countries - like France - which had a large nuclear programme should not have two members on the committee. Küsters said that the same question had been raised internally in Germany, but personally he favoured a small committee. If necessary, specialists could be invited as observers on an ad hoc basis.

Several members said that a large number of participants might reduce the effectiveness of the committee and they would prefer to see specialists on an ad hoc basis. The Chairman shared the concern about the effectiveness of the committee but emphasized that full representation of the technical interests of all the major countries had to be ensured.

It was agreed that no further action should be taken at this stage but the committee would be prepared to discuss the matter again at future meetings.

2. OLD BUSINESS

2.1 Activities of US and NEA centres of interest  
to EACRP

CPL - CCDN

Royen distributed short reports on the activities of CPL and CCDN. He said that CPL had decided to postpone its pilot study of a modular system as no such system had been made generally available. He added that CPL's new activity, SECU (Service of Experience on Code Utilization), had started with a pilot study on a number of codes for shielding purposes. Dr. G. Hehn from Stuttgart, Dr. C. Devillers from Saclay and Dr. C. Ponti from ESIS served as experts to CPL in this activity. About 300 questionnaires had been sent out to laboratories within the NEA member countries in order to collect information on users' experience.

During the discussion several committee members expressed concern about the large number (8) of codes chosen for the study. It would have been preferable to limit the exercise to  $S_n$  codes. They further felt that proper feedback was missing in this part of CPL's activity. It was essential that all the users should have the benefit of mutual experience.

Royen said that a report covering the present study should be ready early in 1974, i.e. well in advance of the next meeting. It could be considered at that meeting and possible further recommendations could be forwarded to CPL after discussion at that time.

Concerning CCDN Buistraan reported on a co-operative arrangement on exchange of information and data between CCDN-CPL and the corresponding US centres. A short extract from the draft arrangement was distributed.

US centres

Hannum reported that ANL had been designated as the US centre for AEC code exchange, broadening its coverage of codes beyond that of codes of particular nuclear interest. Reference codes for shielding would be available at the ANL

code centre, whereas developmental codes would continue to be handled by RSIC. RSIC had furthermore included controlled thermonuclear reactor codes in its activity.

Hannum further said it was the intention to use the cross-section centre at Brookhaven as a formal distribution point for processed data sets as well as for the basic ENDF/B libraries. A group set generated by a special user would in this way also be available for other users. This was expected to be particularly valuable for the universities. He asked whether such an activity was also planned at CCDN.

Royen agreed to find out whether CCDN intended to include the distribution of processed data sets in its programme.

## 2.2 Request from EANDC

The Chairman of EANDC, Dr. Story, had sent a letter to the committee members asking for views on the accuracy required for various detector cross-sections. Farinelli enlarged on this and said that there was an increased demand for accurate cross-sections for detectors used for dosimetry purposes. The topic had been taken up by the Euratom Working Group on Reactor Dosimetry, by INDAC, and by the Nuclear Data Section of IAEA and the Cross-Section Evaluation Working Group (CSEWG) in the US, and the Interlaboratory Reaction Rate Group. A consultants' meeting was to be organized by IAEA in September.

The matter was discussed briefly but members were not prepared to make any quantitative statements concerning target accuracies.

Campbell raised the question as to whether data such as fission yields,  $\gamma$ -rays from fission products etc. (termed chemical data in the UK) should, from the request point of view, be treated in the same way as neutron cross-section data.

Dr. Smith said that EANDC handled requests for such data in the same way as other requests. RENDA covered not only cross-sections but also fission product yields and

EANDC would apply the same priority principles in recommending measurement programmes for such data as for the classical neutron cross-section data.

### 3. NEW BUSINESS

#### 3.1 Organization of the seventeenth meeting; agenda, time, place, participants

The committee accepted an invitation from Bussac on behalf of the CEA, France, to hold its 17th meeting at or near Cadarache in the last week of May 1974. The Secretariat would seek the necessary authorization.

The preliminary agenda is given in Annex 5.

#### 3.2 EACRP observers at the next EANDC and CREST meeting

Hirota would represent EACRP at the EANDC meeting in Tokyo (March 1974).

Bussac would serve as an EACRP observer at the forthcoming CREST meeting (autumn 1974), if an observer were in fact invited.

#### 3.3 Election of officers

The acting officers of the committee accepted to remain in office up to and during the next meeting.

#### 3.4 Classification of EACRP documents

On the proposal of Farinelli the question of proper classification and circulation of EACRP documents was discussed. Farinelli said that many documents that were well qualified for L or U distribution were now classified as A documents. It was important that the information in the EACRP documents should reach the people working in the various areas. The L distribution list contained persons well acquainted with technical subjects, and the fact that a report was provisional should not prevent its distribution to those on the L list.

There was a general consensus within the committee that more reports should be given L and U distribution. It was also agreed to review the list of documents presented at the Zürich meeting, changing the classification of those A documents that merited an L or U distribution. The reclassified documents are listed in Annex 6. The committee further decided that the agenda for future meetings should include discussion of classification of documents so as to ensure the widest possible distribution of EACRP reports.

It was recognized that reproduction of a large number of copies of a report - as requested for L and U distribution - might be a burden for the organization from which the report originated. It was suggested that abstracts might go out to everyone on the distribution list with a note saying that full reports were available upon request, but no definite recommendation was made.

It was decided that the business part of the minutes should be given A distribution and the technical part L distribution.

PART B. TECHNICAL SESSIONS

1. GENERAL

1.1 Review of recent activities, national programmes, discrepancies, evaluation work

The reports prepared by the EACRP members and corresponding members were presented and discussed. The reports are listed in Annex 7, together with the other papers distributed at the meeting.

Dr. Spano spoke about meetings which IAEA planned to hold and were of interest to the committee. A list of these and some other meetings is given in Annex 8.

1.2 Report on the 8th meeting of CREST

Royen gave a short account of past and planned activities of CREST. The Steering Committee of NEA had decided that the responsibilities of this committee should be expanded to cover not only reactor safety but also licensing. As a result, a new committee had been set up on safety of nuclear installations. The current CREST activity would probably continue within a subgroup of the new committee. To ensure continued contact between EACRP and that body, an action was put on the Chairman to write to the Director-General of NEA.

1.3 Highlights from recent meetings of interest to EACRP

Fourth International Conference on Reactor Shielding

A summary report had been distributed by IAEA, and ESIS had published a review of the meeting. Hence no detailed account of the meeting seemed necessary. Maienschein observed that the nuclear data discussion had been only qualitative but it was to be expected that the next meeting would mainly be concerned with studies of the sensitivity of shield performance to cross-section sets (cf. B 2.2). The meeting had further dealt with the two approaches to the problem of obtaining

reliable group cross-section sets, i.e. generation from microscopic cross-sections and checking against clean benchmark experiments, and using adjusted group cross-sections with the adjustments being made on suitable series of integral experiments.

There had been a substantial measure of agreement on the need for benchmark experiments, and on the choice of measuring techniques and types of experimental facilities. It had been pointed out that in the case of earlier experiments meaningful comparisons between experiments and new calculations had often not been possible because the geometry, the source, the material compositions or the detector configuration etc. had not been adequately described.

ANS National Topical Meeting on New Developments  
in Reactor Physics and Shielding, Kiamesha Lake

Hannum distributed a short summary report on this meeting. He said there had been a free and interesting discussion, with many good papers. He had found the discussion on the effect, in reactor context, of the  $(n,\gamma,n')$  reaction and the technique of bilinear weighting in cross-section collapse to be of special interest.

Jülich Topical Meeting: Status of and Requirements  
for the Production of Physical Parameters for  
Thermal and Fast Reactors

Küsters said that this meeting was the first of a series of three. It dealt with reactor physics and thermo-hydraulics problems in fresh cores. Among the topics discussed were the need for 3D power calculations in thermal reactors, the discrepancy in predicting the temperature dependence of reactivity and the need for methods to treat heterogeneity effects in LWR assemblies containing graded plutonium enrichment. Most papers had given an account of the status of the ability to predict various parameters but with little reference to the accuracy needed. Little had been said about the costs of improving present techniques and the benefits that could be obtained from such improvements.

Nuclear Data, Paris

Farinelli reported that little of importance for fission reactors had come out of this meeting. The most important application of nuclear data outside the reactor field was activation analysis.

Numerous sophisticated applications had been reported and many evaluations of non-neutron data had been presented. A summary will be given in ESIS' Newsletter.

Royen mentioned that the International Working Group on Nuclear Structure and Reaction Data had met after the conference. It had been decided to organise an international survey of nuclear data needs in activation analysis and of the available compilations (of decay data, of neutron cross-sections, of charged particle cross-sections, of handbooks on activation analysis, etc.), with Kernforschungszentrum Karlsruhe, Germany, serving as the receiving centre. IAEA would be deciding on further actions after these compilations had been reviewed.

1.4 Report on the sixteenth EANDC meeting

Bustraan reported on this meeting and concentrated on the discussions concerning a widened scope for the committee. The need for data for purposes other than fission reactors would increase and EANDC would have to adjust itself to these needs. This might entail a change in structure of the committee, dividing it up into an executive section and a technical one. The meetings of the latter could be ad hoc specialists' meetings, convened to discuss special topics and reporting back to the main committee. The matter was to be considered further at the next EANDC meeting.

Dr. Smith added that EANDC at its last meeting had again recommended that the Joint Sub-Committee (JSC) be abolished. EANDC had felt strongly that specialists' meetings of the type that had been organized lately were more efficient than ad hoc meetings of JSC.

The Chairman noted the position of EANDC expressed at the Stockholm meeting where the committee had been against making JSC a standing body, preferring specialists' meetings to ad hoc JSC meetings. The same stand had been taken at the Zürich meeting.

During the discussion that followed, committee members expressed no objection to abolishing the JSC. Specialists' meetings were to be preferred and the discussion centered upon questions relating to the sponsorship and organization of such meetings. Flexibility was desirable and meetings could be sponsored or endorsed jointly by EANDC and EACRP, or by either one of these each committees. As for organizational matters, NEA, in collaboration with Euratom and national laboratories, provided the natural channel for the arrangement of these specific meetings. Committee members should be notified well in advance of the meetings, in order to ensure maximum participation from the USA and Japan.

#### 1.5 Compilations

##### LWR compilation

Farinelli gave a status report on the LWR compilation. He said that the second part would be somewhat different in scope and organization than the first part; for instance, a number of experiments that involved heterogeneities would be included. The data would be carefully checked for completeness and consistency, and the data sheet format would be different from that in the BNL volume. Most of the material had been collected and a draft for limited circulation was scheduled for the end of the year. There was some possibility of including data from the Eastern countries.

Tyror said that in his opinion a critical review of the data was to be preferred rather than an extension of the number of experiments. A limited number of carefully evaluated experiments would be very valuable for testing calculational methods. Farinelli said that a number of experimental results had been omitted and thus some screening had been done.

#### Fast reactor compilation

Hannum reported that the group at Atomics International responsible for compiling fast reactor experimental data would shortly cease to be active in the physics field. A survey was being made to find out whether there was a real need for the compilation in question. He asked the committee for its views on the usefulness of this compilation.

Hellstrand said that data from the experiments used as benchmark criticals would certainly be of interest and he wondered whether a list of these criticals was available.

Hannum replied that such a list could probably be made available.

#### "Clean lattice" compilation

A draft prepared by Casini was circulated but in his absence no discussion took place.

#### Shielding benchmarks

Maienschein said that a subcommittee had been formed within CSEWG to consider shielding experiments in the US and designate a number of these as benchmarks (a list of the selected experiments is given in Annex 9). To qualify as benchmarks the following information had to be available:

- (i) For the source: intensity, energy distribution and angular distribution;
- (ii) For the shield and its surroundings: material composition and geometry;
- (iii) For the detectors: energy dependence, magnitude of response and angular dependence.

He pointed to the usefulness of having an exchange of information and experience in the shielding field among the countries represented in EACRP and wondered whether such an exchange could not be organized in some way, such as by making compilations in a given format, exchanging reports etc.

Campbell said that such questions had not so far been adequately covered in Europe but they were now being given full consideration. Several experiments performed for PFR would

not qualify as benchmarks but they still constituted very useful experiments for the design of a particular shield. On the experimental side a new fission plate facility was being commissioned on NESTOR and it was going to be used in connection with some well-defined experiments.

Farinelli informed the meeting that the ESIS newsletter would shortly report on two shielding experiments performed in Italy. One concerned the propagation of neutrons in a large block of iron with an enriched uranium converter as the source, while the second (carried out at Ispra) concerns neutron propagation in laminated iron-water shields. Also at Ispra, an experiment to determine the gamma production in iron has been carried out.

There was general agreement in the committee about the desirability of co-ordinating the work being done in connection with shielding. To help establish such co-ordination the committee agreed to make the following recommendation:

"EACRP recommends that the European and Japanese communities each consider the programme of benchmark shielding experiments to be undertaken in their areas as tests of data and of methods in support of energy deposition and penetration calculations. EACRP further recommends that the North American, European and Japanese communities should mutually exchange their shielding benchmark information. Note should be taken of the format used for benchmark shielding experiments in the U.S.<sup>x</sup> and it is recommended that it should be adopted with modifications as required."

Progress in this area should be reviewed at the next EACRP meeting and already completed benchmark experiments should be reported at that time. Such reports should include the required detailed specifications for source and detector and the geometries of all materials including the surroundings of the experiments. Work in progress should be indicated for the minutes.

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<sup>x</sup>) This format was illustrated in ORNL-TM-3957 (by R. E. Maerker) which was distributed to EACRP members prior to the 16th meeting."

## 1.6 Miscellaneous

During the discussion of benchmark problems in connection with the agenda for the next meeting, Bussac offered to define a test case for 2D box calculations (LWR). From the general discussion of thermal reactor problems, it emerged that there was a need for reactor physics data from operating power reactors and committee members were asked to enquire into the availability of such data in their respective countries.

## 2. INFORMATION ON MEETINGS RECOMMENDED BY EACRP

### 2.1 Specialists' meetings

#### Structural materials

Küsters presented a written summary of the meeting and only a few comments will be included here. Küsters said that the official conclusions of the meeting were not yet available but the papers that had been presented and a summary would shortly be published as a KFK report with EACRP-U- and EANDC-U- distribution.

The participants had been a balanced mix of cross-section measurers, evaluators and reactor physicists. Concerning the required accuracy, the reactor physicists had as their target  $\pm 10\%$  for stainless steel in the energy range 1 keV to 1 MeV. Such an accuracy was still far removed from what was available today. Moxon claimed for instance that the uncertainty in  $\Gamma_{\gamma}$  for Fe was of the order of 40% but this figure was disputed by Fröhner and others. They considered the uncertainty to be nearer 15 to 25%. Recent evaluations had been made in the UK and group cross-sections had been included in the FGL5U set. Applied to ZEBRA 8C this set had given good results. The participants had considered the meeting to be very useful.

#### Bologna meeting on evaluated nuclear data formats

Farinelli circulated a preprint of the proceedings of the meeting and summarized the conclusions. Codes were now available for making all necessary translations between the main libraries. However, automatic translation is not recommended:

consistency tests on integral quantities should always be performed, and the best approach is considered to be the combination of the use of a conversion code with a certain amount of evaluation effort. Requests were being made for inclusion of error estimates in evaluated data files and these would to some extent be met in ENDF/B IV. The possibility of introducing a universal format was discussed and the ENDF/B IV format was considered as fulfilling most of the requirements for such a format. A problem insofar as international co-operation was concerned was the lack of adequate information on the different codes. Several forthcoming issues of the CCDN bulletin would therefore contain a description of various manipulation codes etc.

Hannum put forward a US proposal whereby the CCDN and BNL cross-section centres would act as focal points for the collection of available codes which converted evaluated cross-section libraries from one format to another, and for providing corresponding centres with such codes.

The committee members did not make any specific comments on Hannum's proposal. Royen was asked to take up the matter with CCDN.

## 2.2 New meetings

Proposal for new specialists' meetings to be sponsored by EACRP were put forward and discussed in depth. Several sub-committees were formed to draw up the objectives of the meetings recommended. Various members accepted to assist, more or less directly, in arranging the meetings (cf. actions 20 to 28, Annex 4).

The committee was in favour of convening meetings on:

- (i) Resonance parameters for U238 and Pu239  
Suggested date: late 1973  
Organization: through Euratom (Ribon)

- (ii) Codes for nuclear data processing  
Suggested date: late 1973  
Organization: through CPL with Farinelli as the EACRP contact
- (iii) Monte Carlo specialists' meeting  
Date: before summer 1974  
Organization: Küsters and Hannum.  
The objectives of this meeting are given in Annex 10a
- (iv) Follow-up of EACRP kinetic benchmark experiments  
Suggested date: spring 1974  
Organization: through CREST with Küsters as the EACRP contact (cf. B 4.1)
- (v) Methodology for sensitivity studies with regard to shielding data needs  
An IAEA meeting on nuclear data needs for shielding was scheduled for 1974. The committee felt that much development work was now being done on methodology for sensitivity studies. As the sensitivity studies were a prerequisite for defining the nuclear data needs, a meeting on the methodology for such studies would be preferable to the proposed IAEA meeting. The Chairman undertook to write to IAEA (Gr. Chernilin) expressing the committee's views.
- (vi) Specialists' meeting on reactor noise  
Date: autumn 1974  
Organization: CNEN (Farinelli)  
The suggested objectives of the meeting are given in Annex 10b

The following topics were carried over for further discussion at the next meeting.

- Inelastic cross-section of U238 and Fe
- $\gamma$  production cross-sections
- Fast neutron fission spectra.

### 3. TOPICS FROM PREVIOUS MEETINGS

#### 3.1 $\beta$ values. Reactivity scales

##### UK

Campbell gave an account of the paper EACRP-L-82 which summarized the UK position on the problem of central perturbation discrepancies and the consistency of various reactivity scales.

Four different scales had been compared in large ZEBRA assemblies. These were in turn based on:

- (a) the  $\beta_{\text{eff}}$  scale (BEF)
- (b) the reactivity worth of a small central plutonium sample (CPS)
- (c) the edge fuel addition scale (EFA)
- (d) the inner core depletion scale (ICD).

The inner core depletion technique was a new approach which was considered important for two reasons. The result using this technique depended sensitively on correct estimates of the real and adjoint fluxes, and the scale as such related closely to the reactivity changes resulting from burn up.

The C/E values of the various scales relative to that of the  $\beta_{\text{eff}}$  scale agreed within 8 %. The  $\beta$ -values used for the latter scale were those recommended by Tomlinson and discussed at the last EACRP meeting. As a whole, the uncertainty of the reactivity scale was now small enough not to be of any great concern.

##### Discussion

Hannum said that there was a tendency in the US to go back toward the old Keepin data for delayed neutrons. These data differed from those of Tomlinson and using the Keepin data would increase the central worth discrepancy.

Küsters said that Fischer was making a new evaluation of the  $\beta_{\text{eff}}$  measurements in SNEAK. It was thought that the big increase in  $\beta_{\text{eff}}$  for plutonium found earlier would be reduced.

Hellstrand briefly referred to the measurements of delayed neutron spectra by Rudstam et al. at the R2 reactor at Studsvik. By having a mass separator directly attached to the reactor, and with the ion source with its U235 target placed in a neutron beam, measurements could be made on separated short-lived fission products. An He3 spectrometer was being used for the spectrum measurements.

Farinelli reported on central reactivity worths in Tapiro. Good agreement had been obtained for U235 but there was a 20 % discrepancy for U238.

### 3.2 3D benchmark comparisons

Micheelsen gave a summary of a 3D benchmark test that had been recommended at the IAEA burn up panel in 1971 (EACRP-U-47). Most results had been obtained from computer codes using finite difference technique, but also contributions based on nodal, synthesis and coarse mesh codes were received. The results from the calculations relying on finite difference technique were expected to agree, but the flux level differed in certain regions by as much as 20 to 40 %. The difference was found to disappear when the number of mesh points was increased. It was due to the fact that for one type of finite difference codes the flux at the mesh centre was used whereas for the other type of codes the flux at the mesh corner was used. It was thus clear that one had to be cautious when using finite difference codes and had to go to high mesh numbers to get an accurate result. Such a contribution was not received.

The approximate methods seemed to give reasonable results in the sense that they gave as good results as the finite difference technique code they relied on. Most codes had given good estimates of  $k_{\text{eff}}$ .

The committee found the 3D exercise interesting but regretted that results from a very accurate calculation were not available. There was no US contribution among those compiled and Hannum said he would draw the attention of US reactor firms to the 3D test case and try to persuade them to send in a solution to Micheelsen.

Farinelli asked whether a clean 3D experiment in a critical facility would be of interest for testing of global 3D codes. It might be possible to devise and perform such an experiment at Casaccia.

Several members of the committee pointed to the difficulty of performing a really meaningful experiment of this kind. It was agreed that Farinelli would send out a proposal for comments if the experiment could be made.

#### 4. NEW TOPICS

##### 4.1 Space-time dynamics

###### Germany

Küsters presented the paper EACRP-L-84. Two approaches were being followed for LMFBR transient analyses - one used variational principles with time-discontinuous trial functions, the other being the quasi-static approach. The aim was to have an integrated code system including all feedback effects of importance in accident analyses.

The first of these two approaches had led to the code RADYVAR2. It contained among other things a new improved module BLOW3 for multi-bubble treatment of sodium, including vapour flow inside the bubbles. The module had been checked against experiments performed at Karlsruhe. The fuel-coolant interaction was calculated in two phases, the first with the equations given by Cho and Wright and the second according to the model by Caldarola.

The quasi-static code, KINTIC, had the same feedback parts as RADYVAR. Although KINTIC was partly developed for checking RADYVAR, the quasi-static approach had been chosen rather than the full numerical code in order to save computer time. It was being included in a large modular code system containing static as well as dynamic codes. Both RADYVAR and KINTIC would be used for the EACRP benchmark problems.

The work being done in Germany also included an investigation (W. B. Terney) of how to perform group collapsing in fast reactor dynamic calculations. Large differences had been found between results of calculations using normal flux collapsing and those using bilinear weighting. The energy synthesis technique had also been used and the conclusion was that this method and that based on bilinear weighting both gave results that were in good agreement with multi-group calculations.

#### Italy

Farinelli reported that a 2D dynamics code for fast reactors was being developed at CNEN. It was intended primarily for dealing with special problems in the PEC reactor. The central part of the core would contain three loops, neutronic-ally coupled but uncoupled as far as thermohydraulics was concerned. The code was to be used for accident transients as well as operational ones.

Farinelli also introduced the Ispra report EACRP-L-83 which described the latest developments with regard to the CONSTANZA series of space dynamic codes.

#### Denmark

Micheelsen referred to the 3D non-linear kinetics code ANDYCAP which had been developed as a joint Scandinavian venture. The code was operating for BWR systems and experience with this code had shown that three-dimensional treatment was essential. (Küsters mentioned that Dr. Birkhofer had expressed the same opinion.)

UK

Tyror reported that the time dependent effects which were currently of greatest interest in the UK for thermal reactors were those related to normal operating conditions such as part load, start up, shut down etc. The emphasis was very much on trying to establish fuel performance - fission product gas release, build up of pressure within pins, thermal stresses in the clad materials etc. These problems were not dynamic problems in the normal sense but they involved the time variable.

Discussion

Küsters raised the question as to whether space-time dynamics calculations were really necessary for fast reactors. He quoted two cases in which they were superfluous: the pump coast-down accident with fuel moving downwards to the central part, and large power reactors in which different parts were only loosely coupled to each other. In the first of these cases, the positive ramp caused by sodium ejection from the central part might cause the core to disassemble before any fuel movement occurred towards the centre, making space-time treatment unnecessary. As for the second, Küsters thought 2D or even 3D would be necessary. A proper balance had to be maintained, however, between the degree of sophistication in the treatment of the space-time dependence and the description of the feedback mechanisms.

Hannum and Loewenstein agreed that the large loosely-coupled systems would call for 2D or 3D treatment but basic models for fuel pin ruptures etc. were needed as well.

Dynamic benchmark problems

Küsters reported on the present status of the response to the EACRP benchmark test problems. The problems had been sent out too late for a massive response to be received from the member countries before the present meeting.

Four results for the 1D problem were the only ones received so far. There were some differences in the results but, as a more thorough comparison would be made when other contributions had come in, no detailed examination of the discrepancies had been undertaken.

It was decided that the new deadline for sending in results would be October 1973. The results should be sent to Küsters who would undertake the compilation with the help of the originators. A benchmark review meeting should be convened before the next EACRP meeting, to discuss the results.

Royen reminded the committee that CREST was organising a specialists meeting in space-time dynamics in late 1973.

The committee would, however, prefer a benchmark review meeting to a more general type of session. Küsters agreed to contact Dr. Birkhofer of CREST and suggest that a joint EACRP-CREST meeting be convened for a review of the benchmark calculations. If he were invited to the new CREST subgroup meeting late in 1973 he would again press for the type of meeting EACRP wanted. Royen undertook to transmit to CREST the recommendation of EACRP concerning the review meeting.

#### 4.2 Studies of the sensitivity of shield performance to cross-section sets

##### Japan

Hirota summarized the two Japanese report EACRP-L-86 and EACRP-A-201. The first gave results from fast neutron transport calculations in graphite, iron and sodium. The purpose of the work had been to check the basic nuclear data and assess the calculation methods. The three ENDF/B files and the KFK data set had been used.

The study had shown that the ENDF/B graphite data were in satisfactory shape whereas for iron the angular spectra in certain directions were underestimated by the

calculations. Comparison between measured and calculated data for deep penetration in sodium gave fairly good agreement using ENDF/B III cross-sections.

The second paper was a study of the sensitivity of the calculated neutron flux in iron shields to cross-section errors in the input data. The energy dependence of the elastic, inelastic and total cross-sections as obtained from different compilations had been compared. The angular spectra had been calculated for a given shield and compared with experimental results. The conclusion was that the data for elastic scattering needed to be re-evaluated and the same was true of the inelastic cross-section at high energies.

#### France

Reporting on the activities in France (EACRP-A-200) Bussac said that the sensitivity to cross-section data had primarily been studied in connection with calculations on thick iron shields. Different cross-sections had been used and the results had been compared with experiments. Inaccuracies caused by the difficulty of deriving proper multigroup cross-sections for iron had been found to be just as important as the uncertainties in the cross-sections. Attention had likewise been given to the general problem of reducing the number of energy groups in multigroup calculations without seriously affecting the accuracy. This work would continue. Other future activities would include determination of the sensitivity of calculations to uncertainties in cross-sections and in the radiation source. Requests for new measurements and data evaluations would be scrutinized.

#### US

Maienschein gave a summary of the papers EACRP-L-85 and EACRP-A-206. The first dealt with the sensitivity of calculated shield performance to nuclear data variation. The field was fast developing and the interest lay in determining the effect on radiation transmission through a shield of changes in the input parameters. A mathematical procedure had

been worked out based on first-order perturbation theory to determine cross-section sensitivity profiles. The use of these profiles would include guidance in further data evaluations and measurements, particularly with regard to the energy region of importance. They could further be used in optimizing the number of groups and the group boundaries for particular problems, and they could be used to estimate the uncertainty in calculated quantities using given uncertainties for the cross-section data. Correlations between cross-section uncertainties had to be included but this had only been done in a simplified manner up to now.

Several examples of conclusions that could be drawn from sensitivity profiles were given. For instance, from a 50-group perturbation calculation on a thick sodium and iron shield it could be seen that the tissue dose rate would change by 10 % for a 1 % change in the total Na cross-section per lethargy unit. From another example it was obvious that high-energy neutrons (10 MeV) were of great importance for the dose transmitted through thick shields and consequently the cross-sections at these energies had to be known fairly accurately.

It was the intention to use the same method also for core physics parameters, either for a direct determination of the uncertainties in these quantities or to lay down the requirements on the most important cross-sections to meet certain target accuracies for the parameters in question.

The second paper concerned the inclusion of error files in ENDF/B. Version IV would be provided with fairly complete error files for two materials and partial error files for about 10 nuclides. The errors would be given as standard deviations and they would be included in such a way that the existing processing codes could be used ignoring the error files if so desired.

### Discussion

Campbell said that adjustment of group cross-sections based on integral experiments was an accepted procedure in the UK for obtaining adequate cross-section sets. Sensitivity studies could be made using such sets, and this would reduce the number of requests for differential measurements. In the case of iron, for instance, results from integral experiments could perhaps have been used to infer data for the big resonance in Fe that would have given the same results for practical shields as the new parameters obtained by differential measurements.

Maienschein and Hannum said that adjusted cross-section sets would work well for those geometries for which they were obtained but it was less certain how adequate they would be for new types of shields. In addition, properly performed sensitivity studies would focus very sharply on those few cross-sections which were really important and the experimental effort could then be concentrated there.

Dr. Smith said that the elastic cross-sections were not known with good energy resolution ( $> 10$  keV) and he further pointed to the difficulty of experimental determination of the parameters that caused the window effects.

Bussac asked whether integral experiments on thick iron shields could be used to obtain adequate data for the windows in the iron cross-section. Experiments had been performed in France a few years ago but the agreement between calculated and experimental results for the transmitted dose rate was poor.

Farinelli pointed out that ENDF/B III already contained some 11,000 data points for Fe and he wondered how these should be used. He also asked whether from now on it would not be better to perform adjustments on condensed data sets rather than to produce still more differential data points.

Maienschein said that sensitivity profiles should be used to obtain a tailored condensed set from the microscopic data that would meet a given requirement as to accuracy.

Küsters said that sensitivity studies should be applied not only to cross-sections but also the calculation methods. Campbell added that it was necessary to make a distinction between very accurate and detailed calculations using the very best cross-section data and practical shield calculations using approximate methods. The latter often needed nuclear data of their own.

As for the accuracy required in typical shield calculations it was stated that the dose rate above a fast reactor should be known within, say, a factor of 2 (Maienschein). For the external biological dose rate the target accuracy should be a factor of 2 to 5 (Campbell). Campbell also said that the most urgent need in the shielding area in the UK was adequate data for energy deposition, particularly in components not containing fissionable material.

#### 4.3 Discrepancies in predicted temperature coefficients for thermal reactors

##### UK

Tyror presented the paper EACRP-U-49. He mentioned that for graphite reactors there was a considerable economic interest in knowing the temperature coefficient within about  $0.5 \times 10^{-5}/^{\circ}\text{C}$ . For LWRs the requirements were less stringent. The basic lattice code in the UK was WIMS which could be used in different variants for LWRs, SGHWRs and graphite reactors. When compared with experiments on small critical or exponential  $\text{H}_2\text{O}$  systems, results from WIMS calculations overestimated the temperature dependence by  $4$  to  $5 \times 10^{-5}/^{\circ}\text{C}$ , while the discrepancy was considerably less for a power reactor case that had been studied (Yankee). For SGHWRs the overprediction of the temperature coefficient was  $3$  to  $4 \times 10^{-5}/^{\circ}\text{C}$ . The graphite systems were generally more accurately predicted; the uncertainty was of the order of  $1 \times 10^{-5}/^{\circ}\text{C}$ . When applying WIMS to AGRs and HTGRs in the past, larger discrepancies had been experienced but the situation had been improved by introducing a modified scattering law for graphite.

### Sweden

Hellstrand gave a summary of the paper EACRP-A-205. Large series of hot critical experiments had been performed in the KRITZ facility at Studsvik for both uranium-fuelled and plutonium-fuelled systems. The results had been compared with calculations using the lattice code AEBUXY. The comparisons showed a tendency similar to that reported by Tyror, with the overprediction ranging from 2 to 4 x 10<sup>-5</sup>/°C. The discrepancy was practically the same for uranium and plutonium systems. It had been found that the deficiency in the calculated reactivity variation with temperature was almost independent of temperature in the range studied, indicating that leakage effects could not be the predominant reason for the discrepancy. New experimental results on high-enriched plutonium systems were to be analyzed in the near future and the results of these analyses might throw some new light on the problem.

### Canada

Duret very briefly presented some comparisons between measured and calculated data for Canadian power reactors (EACRP-A-204). Measured data were available for fresh and irradiated cores. The agreement between calculated and experimental values was better for the coolant coefficient than for the moderator (Douglas Point). The existing discrepancies were small and of no practical concern.

### France

Bussac introduced a paper (EACRP-A-203) devoted primarily to the temperature coefficient of graphite systems. Discrepancies had previously been eliminated by an adjustment of the U235 absorption cross-section vs energy. The paper dealt with another possible cause, namely, a resonance structure in the U238 capture cross-section in the thermal region. Although such a structure might not explain the entire discrepancy, new measurements on U238 were recommended at thermal energies.

During the discussion it was concluded that the problem of correctly predicting the temperature coefficient of reactivity for LWRs had not yet been entirely resolved. Uncertainties in the cross-sections for U238 and U235 might contribute to the discrepancy, and the Chairman undertook to send a letter to EANDC asking about the status of cross-sections that were of importance for the temperature coefficient.

#### 4.4 Comparison of adjusted and unadjusted group cross-sections

##### US

Hannum briefly referred to two papers relating to this subject. The first, by S Pearlstein, Director of the Cross-Section Evaluation Center at Brookhaven, contained the author's views on the evaluated data file, ENDF/B. In his opinion the file should be based on measured microscopic data but in the evaluation procedure consideration should be given to integral measurements so that the data base would be consistent with microscopic and integral measurements. He was not in favour of using an adjustments scheme based only on integral data.

The second paper (EACRP-L-87) contained a discussion of the specification of multi-group structure for neutron transport calculations.

##### UK

Campbell summarized the work in the UK (EACRP-L-88) in the fast reactor field. Starting with an evaluated multi-group set ( $\sim 2000$  groups) a first adjustment was achieved by only changing the U238 absorption and fission cross-sections. Further, it had been found that the integral experiments were insensitive to a number of cross-sections. These could therefore be omitted from the adjustments. The final adjustments were made in 10 energy groups with the LSQ programme and an adjusted fine group set, FGL5, was obtained from the factors determined by LSQ. Calculations with the new set had been found to agree well with integral experiments. He had some

comments to make on the general pattern of the adjustment. In the MeV region a flux increase had been found necessary; this was achieved by increasing the mean energy of the fission spectra for U235 and Pu239 and by changing certain cross-sections. At lower energies a reduction of the capture cross-sections below 25 keV was required, while the same was true for the scattering cross-sections above 25 keV. The spectrum measurements had been important in obtaining these latter results. The adjustments that came out from the LSQ fits were sometimes considerably outside the assumed standard deviations for the differential data.

A number of calculations had been made with the new set and it had been found to predict various quantities quite well, including the neutron spectrum. The new set was believed to calculate  $k_{\text{eff}}$  for large fast reactors within  $\pm 0.3\%$  and to predict the breeding gain within an uncertainty of  $\pm 0.03$ .

#### Japan

Presenting the paper EACRP-A-207 Hirota said that the adjustment procedure used in Japan was based on the LSQ method using 15 energy groups. A special computer system, ARCADIA, had been employed to adjust the fine group set AGLI (1950 groups) using the information from the LSQ results. The correlation between cross-sections belonging to different nuclides (due, for instance, to a common standard in the measurements), as well as the correlation of a particular cross-section between one energy region and another, was important and had to be taken into account. The adjustment led to an improved set AGLI/1, but certain changes in the cross-section data were far outside the uncertainties of the measured data. The adjustment procedure was therefore to be repeated, starting from a set AGLI/2U from which the inconsistencies referred to had been removed. It was expected that a reliable set to be used for reactor calculations would be available after the adjustment of AGLI/2.

### Italy

Farinelli said that the Italian approach was similar to that followed in the UK. Integral experiments from ZPR-6 and SNEAK had recently been used for adjustments. The results were summarized in the paper EACRP-L-89. The original cross-section set was based on ENDF/B III and the adjustment was performed in 27 groups. The modifications of the cross-sections that resulted from the adjustment calculations included a reduction in the U238 capture cross-section below 800 keV (except in the interval 10 to 25 keV) and the same for fission in U235 between 10 and 100 keV.

### Sweden

Hellstrand summarized the paper EACRP-A-208 which described adjustments based on the Swedish code system JOHN (similar to LSQ). Fourteen integral quantities had been used and the starting cross-section set was based on ENDF/B III. The adjustments required were generally small except for the transport and slowing down cross-sections of iron between 180 and 800 keV, for which changes of the order of 50 % were needed.

### France

Bussac gave an account of French work in the adjustment field. Adjustment techniques had been applied in a limited way in the thermal reactor field. The cell and assembly code APOLLO had been used for calculations on various clean systems. Adjustment had then been made on five integral parameters to get the best overall fit. The changes made included a reduction of the effective resonance integral for U238 by 0.8 b, a small decrease in  $\nu$  for Pu239 and an increase of  $\sigma_c$  for H<sub>2</sub>O by 2 %. Calculations using ENDF/B and UKNDL cross-sections had been compared. ENDF/B III was found to give the correct value of  $\tau$  but UKNDL failed to do so. In the resonance region, on the other hand, the latter file had been found to give better results than ENDF/B.

For fast reactors, the application of the adjustment technique had resulted in a new cross-section set, Cadarache set III. A variety of French and foreign critical experiments had been utilized, and the integral parameters used were material buckling, neutron balance in PCTR-type experiments and various reaction rates. In addition the data set used had been tested against results from analysis of irradiated samples.

The adjustments were made in six groups and with a limited number of cross-sections as variables. Among the modifications obtained, a net increase of the U238 capture cross-section relative to the fission cross-section of U235, and a decrease in  $\alpha$  for Pu239 and in the capture cross-section of Fe could be mentioned. The situation regarding Fe was particularly puzzling. Evaluation of microscopic data and fitting to integral experiments gave opposite trends. A decrease in capture for Fe would mean large increases in Cr and Ni capture.

Experimental results from ERMINE on plutonium with low and high concentrations of higher plutonium isotopes, respectively, had further indicated that the Pu241 fission cross-section in the present Cadarache set was about 25 % too high.

#### Discussion

The discussion mainly concerned the results found for specific nuclides like iron and the plutonium isotopes. It was concluded that the lack of a common starting data set made it difficult to compare the results of different adjustments. However, direct comparison of adjusted sets was important and it was suggested that a comparison between adjusted cross-section sets should be included on the agenda for the next meeting. Campbell said that the adjusted sets were considered to be of a commercial nature in the UK but values for specific nuclides and energy groups could be given.

Dr. Smith questioned those adjustments that were considerably larger than the estimated error of the microscopic data and he recommended that such adjusted data be used with care. The absence of error limits on evaluated data was noted, and the Chairman agreed to inform EANDC that the committee was interested in having such data included in the files.

#### 4.5 Theoretical and experimental determination of $\gamma$ and neutron energy deposition

##### France

Bussac presented a short paper (EACRP-A-209) containing some general observations on the calculation of the energy deposited by neutrons and  $\gamma$  rays. The paper also included some comments on gamma heating measurements using sintered alumina or lithium glass detectors. A relative accuracy of 5 % had been obtained.

##### Germany

The German paper (EACRP-A-210) presented by Küsters gave some results from calculations on the KNK II reactor with the LEIDI computer programme. Both the neutron and gamma calculations were based on diffusion theory, the general approach being similar to that used by Greenhow. The data library was quite complete, comprising all the important cross-sections and other data of importance for energy deposition.

Experimentally, a type of luminescence detector based on silver-activated metaphosphate glass had been used. The technique had been applied to SNEAK assemblies, with measurements performed both in the core and in the blanket.

##### Japan

The Japanese paper (EACRP-L-90) contained a description of the theoretical methods used together with results of comparisons between calculations and experiments. Hirota said that by suitably defining the  $\gamma$  ray transfer cross-section and the secondary  $\gamma$  ray production cross-section a

code like ANISN with some modifications could be used for dealing with the coupled neutron-gamma transport problem. Calculations had been made in 39 neutron groups and 19  $\gamma$  energy groups. The group constants had been obtained from ENDF/B for neutrons, from MODF-GAMLEG (modified GAMLEG) for the photon transport and from the library POPOP 4 for the secondary gamma ray production. The neutron heat generation coefficients and the corresponding quantity for gamma rays had been generated in a straightforward manner using two special codes. The experiments used for the comparison had been made on two assemblies with identical cores but different blankets. The fission rate distribution had been measured with fission chambers and that of the gamma ray dose by the TLD method ( $^7\text{LiF}$ ). The calculated values for the fission rate distribution agreed well with the experimental ones in the core but were considerably lower than the measured data in the blanket. The discrepancies were larger for the gamma dose rate. The calculations overestimated the effect in the core by about 20 % and underestimated it by up to 40 % in the blanket. Two-dimensional calculations were thought to be necessary to improve the agreement. A separate investigation had shown that errors in the calculation of secondary gamma ray transport could not be the cause of the discrepant result for the gamma ray dose rate in the outer blanket.

#### Ispra

Farinelli summarized the work at Ispra. The approach there was almost identical to that in Japan. The number of neutron and gamma groups were 100 and 20, respectively. The calculation scheme had been worked out for applications on fusion reactors. It would also be applied to the geometries used in connection with experiments on iron at Ispra.

#### Discussion

Campbell said that in certain cases accuracies of the order of 5 % in gamma energy deposition were required.

The experimental technique for achieving such an accuracy was not yet available. TLD and ionization chambers were used in the UK but several problems remained to be solved. Maienschein thought that TLD measurements could be made with an absolute accuracy of + 35 % and with a reproducibility of + 3 %. Hannum pointed out that the use of microcalorimeters to determine small temperature differences might improve the accuracy. The microcalorimeters consist of piezo quartz crystals. By measuring the frequency shift associated with internal expansion, very small temperature differences can be determined.

Hirota wondered whether any benchmark experiments for determining gamma heat generation coefficients were under way or planned. Farinelli said that gamma energy deposition experiments in a large block of iron were being made at Ispra. Blocks of other materials would be used in the future. These experiments could be used as benchmarks. Hannum mentioned that a similar experiment was under consideration in the US, i.e. determination of the secondary gamma ray dose as a function of penetration through large blocks of materials. Campbell said he was in favour of an experiment that was more related to a practical design problem, such as measuring the gamma heat deposition in a rig in the core or in the blanket.

The committee decided to continue the discussion of benchmark experiments, with particular reference to neutron and gamma energy deposition, at its next meeting.

5. TUTORIAL SESSION

The following lectures were given by courtesy of the host organization

1. J. Bussac: The Gabon Prehistoric Reactor
2. J.D. Buffington: What is an Ecological Impact?
3. S.H. Fistedis: Response of Containment of Reactor Components to HCDA (Hypothetical Core Disruptive Accident of an LMFBR)
4. W.M. Stacey: Variational Estimates.

6. OTHER ACTIVITIES

The committee visited some of the laboratories and reactors at the Argonne National Laboratory (CP5, ZGS, The Fast Neutron Generator Laboratory, and The Fast Critical Assembly Building).

A dinner was given by the Argonne National Laboratory.

ANNEX 1

LIST OF PARTICIPANTS

Members

BUSSAC, Jean Marie	Saclay, France
BUSTRAAN, Marinus	RCN, Petten, Netherlands
CAMPBELL, C. Graham	AEE Winfrith, UK
DURET, Maurice (Vice-Chairman)	AECL, Chalk River, Canada
FARINELLI, Ugo	CNEN, Casaccia, Italy
HANNUM, William H. (Chairman)	USAEC, Washington, USA
HELLSTRAND, Eric (Secretary)	AB Atomenergi, Studsvik, Sweden
HIROTA, Jitsuya	JAERI, Tokai-Mura, Japan
KÜSTERS, Heinz	KFZ, Karlsruhe, Germany
LOEWENSTEIN, Walter B.	ANL, Argonne, USA
MAIENSCHIN, Fred	ORNL, Oak Ridge, USA
MICHEELSEN, Bjarne	AEK, Risö, Denmark
TYROR, J. George	AEE, Winfrith, UK

Observers

SPANNO, A.O. (at the technical session)	IAEA, Vienna, Austria
SMITH, A.	EANDC, ANL, Argonne, USA

Secretariat

ROYEN, J.	NEA, Paris, France
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ANNEX 2

FINAL AGENDA FOR THE SIXTEENTH MEETING

PART A. COMMITTEE BUSINESS

1. GENERAL

- 1.1 Participants
- 1.2 Adoption of the final summary record of the fifteenth meeting
- 1.3 Adoption of the agenda
- 1.4 Completion of actions
- 1.5 Committee representation (Secretariat)

2. OLD BUSINESS

- 2.1 Activities of US and NEA centres of interest to EACRP (Secretariat)
- 2.2 Requests from EANDC

3. NEW BUSINESS

- 3.1 Organization of the seventeenth meeting. Agenda, time, place, participants
- 3.2 EACRP observers at the next EANDC and CREST meetings
- 3.3 Election of officers
- 3.4 Classification of EACRP documents

PART B. TECHNICAL SESSIONS

1. GENERAL

- 1.1 Review of recent activities, national programmes, discrepancies, evaluation work (all members)
- 1.2 Report on the eighth CREST meeting (Küsters, Secretariat)
- 1.3 Highlights from recent meetings of interest to EACRP:
  - Fourth International Conference on Reactor Shielding  
Paris, 9-13th Oct. 1972 (Campbell, Maienschein,  
Farinelli, Secretariat)
  - ANS National Topical Meeting on New Developments  
in Reactor Physics and Shielding, Kiamesha Lake, N.Y.,  
12-15th Sept. 1972 (Hannum, Tyror)
  - ANS winter (1972) and summer (1973) meetings (US)

Jülich Topical Meeting: Status of and Requirements for the Prediction of Physical Parameters for Thermal and Fast Reactors, Jan. 1973 (Küstérs)

International Summer School in Romania, "Nuclear Data for Reactor Calculations", 31. Aug. - 9. Aug. 1972

- 1.4 Report on the sixteenth EANDC meeting (Bustraan, Secretariat)
  - 1.5 Compilations (Hannum, Farinelli, Secretariat)
  - 1.6 Miscellaneous
2. INFORMATION ON MEETINGS RECOMMENDED BY EACRP
- 2.1 Specialists' meetings on cross-section data
    - Structural material (Campbell, Küsters)
    - Bologna meeting on evaluated nuclear data formats
  - 2.2 New meetings
3. TOPICS FROM PREVIOUS MEETINGS
- 3.1  $\beta$  values. Reactivity scales
  - 3.2 3D benchmark comparisons
4. NEW TOPICS
- 4.1 Space-time dynamics (All members)
  - 4.2 Studies of the sensitivity of shield performance to cross-section sets (US, UK, Germany, Italy, Japan)
  - 4.3 Discrepancies in predicted temperature coefficients for thermal reactors (Sweden, UK, US, Italy, Germany, Canada, Japan)
  - 4.4 Comparison of adjusted and unadjusted group cross-sections (Italy, Japan, Sweden, UK, ...)
  - 4.5 Theoretical and experimental determination of  $\gamma$  and neutron energy deposition (UK, US, Germany, Japan, Italy)
5. TUTORIAL SESSIONS
6. OTHER ACTIVITIES

ANNEX 3

ACTIONS FROM PREVIOUS MEETINGS

Action No.	Action on	Action required	Action taken
1	HELLSTRAND	Issue draft minutes of the 15th meeting	Completed
2	SECRETARIAT	Issue and distribute the minutes	Completed
3	SECRETARIAT	Circulate draft agenda for the eighth CREST meeting in Paris, 29th-30th Nov. 1972	Completed
4	HEMMIG	Ask Maienschein to follow up the RSIC request for benchmark information and to disseminate information on the Paris benchmark session through the RSIC Newsletter	Completed
5	BUSTRAAN	Represent EACRP at the 16th EANDC meeting in Paris, 27th Nov. - 1st Dec. 1972	Completed
6	KÜSTERS	Represent EACRP at the 8th CREST meeting in Paris, 29th-30th Nov. 1972	Completed
7	SECRETARIAT KÜSTERS	Present a draft agenda of the 16th EACRP meeting for the chairman of CREST and invite a member of CREST to participate in the meeting, if so desired	Completed
8	HELLSTRAND	Ask the next Scandinavian representative on the EACRP committee to present a summary of the results of the 3D benchmark calculations	Completed
9	MEMBERS	Collect comments from those in the member countries who made the calculations referred to in action 8	Completed
10	MEMBERS	Send proposals for topics for specialists meetings on cross-section data to Campbell	Completed
11	CAMPBELL	Serve as contact for proposals mentioned in action 10	Completed
12	CASINI SECRETARIAT	Assure that the proceedings of Bologna specialist meeting on evaluated nuclear data formats are assigned an EACRP-L number	Completed

Action No.	Action on	Action required	Action taken
13	CASINI	Translate collected data on integral experiments into standard form and circulate among participants	Carry over
14	HEMMIG	Advise Casini whom to contact in the US concerning benchmark calculations	Completed
15	CAMPBELL	Transmit in the form of a letter (reproduced in Appendix 9) to the NEA Secretariat the Committee's views on CPL's new activities	Completed
16	HEMMIG	Advise Casini what HTR data is available for inclusion in his compilation	Completed
17	SECRETARIAT	Issue new lists of committee members	Completed
18	CAMPBELL	Forward the fifth biennial report to the NEA secretariat	Completed
19	TYROR	Circulate proposals for a kinetics benchmark problem to members and to the Secretariat	Completed
20	MEMBERS	Comment on the benchmark problem referred to in action 19	Completed
21	KÜSTERS	Act as focus for the benchmark calculations and make at the next EACRP meeting a summary of contributions obtained	Completed

ANNEX 4

LIST OF COMMITTEE ACTIONS

NEW ACTIONS

Action No.	Section of this report	Action on	Action required
1		HELLSTRAND	Issue draft minutes of the 16th meeting
2		SECRETARIAT	Issue and distribute the minutes
3	A.1.5	MEMBERS	Advise Royen as to the acceptance of the new name of the committee
4	A.2.1	ROYEN	Investigate with CCDN if it intends to include distribution of processed data sets in its activity
5	A.2.2	HANNUM	Acknowledge the receipt of Dr Story's letter on threshold detector cross sections, explaining the action taken
6	A.3.2	BUSSAC	Represent EACRP at the "CREST" meeting in Paris, autumn 1973
7	A.3.2	HIROTA	Represent EACRP at the 17th EANDC meeting in Tokyo, March 1974
8	B.1.2	HANNUM	Write to the DG of NEA concerning the desirability of co-operation between EACRP and the group that succeeds CREST. Ask for the invitation of an EACRP member to the new group's first meeting.
9	A.3.4	MEMBERS	Review distribution lists for L- and U-documents
10	A.3.4	MEMBERS	Send stipulated numbers of A-, L- and U-documents to NEA
11	A.3.4	ROYEN	Distribute reclassified lists of EACRP documents including the reports given at the sixteenth meeting to committee members
12	A.3.4	MEMBERS	Provide all participants and corresponding members with a set of documents originating from their own countries
13	B.1.1	MEMBERS	Advise G Tyror on fission product information relevant to the review article at the forthcoming Bologna meeting

Action No.	Section of this report	Action on	Action required
14	B.1.1	HELLSTRAND	Send list of meetings of interest for IAEA, to Dr Spano
15	B.1.3	MEMBERS attending meetings	Circulate, if possible, a summary report of meetings of interest to EACRP as soon as possible after these meetings have taken place
16	B.1.5	HANNUM	Make list of US benchmark experiments for thermal systems available to committee members
17 <sup>x</sup>	B.1.5	MAIENSCHIEIN	Provide a list of US benchmark shielding experiments and distribute to committee members
18	B.1.6	BUSSAC	Define a benchmark test case for 2D box calculations
19	B.1.6	MEMBERS	Investigate the availability of reactor physics data from operating power reactors
20	B.2.2	BUSSAC	Ask Ribon to organize a specialists' meeting on resonance parameters for U238 and Pu239
21	B.2.2	FARINELLI	Together with CPL, make arrangements for a specialists meeting on codes for nuclear data processing
22	B.2.2	HANNUM	Provide name of a US contact for the proposed meeting on Monte Carlo to Küsters
23	B.2.2	HANNUM KÜSTERS	Assist in organizing a Monte Carlo specialists' meeting
24	B.2.2 B.4.1	ROYEN	Transmit to CREST EACRP's recommendation that CREST or its successor arranges a dynamic benchmark review meeting in spring 1974
25	B.2.2 B.4.1	KÜSTERS	Assist in arranging the dynamic benchmark review meeting, if such a meeting is to take place
26	B.2.2	HANNUM	Send letter to IAEA recommending that the planned IAEA meeting in the shielding area should deal with methodology of sensitivity studies with regard to radiation transport and energy deposition

<sup>x</sup>) Action completed, cf. Annex 9

Action No.	Section of this report	Action on	Action required
27	B.2.2	CAMPBELL	Ask Dr J Butler, UKAEA, to represent EACRP in the organization of the meeting referred to in the previous action
28	B.2.2	FARINELLI	Undertake to organize the specialists' meeting on reactor noise
29	B.2.2	HANNUM	Send list of topics for specialists' meetings on nuclear data endorsed by EACRP, to EANDC
30	B.3.2	HANNUM	Publicize to US firms the 3D benchmark comparison programme and invite participation
31	B.3.2	FARINELLI	Circulate proposal for a 3D benchmark LWR experiment, if such an experiment can be performed
32	B.4.1	MEMBERS	Send results of dynamic benchmark test cases to Küsters. Deadline October 1973
33	B.4.3	HANNUM	Send letter to EANDC regarding the status of cross sections that could affect thermal reactor temperature coefficients
34	B.4.4	HANNUM	Notify EANDC that EACRP wished to have error analyses made on evaluated data and compilations

CARRIED OVER FROM THE 16th MEETING

1	CASINI	Translate collected data on integral experiments into standard form and circulate among participants
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## ANNEX 5

### PRELIMINARY AGENDA FOR THE SEVENTEENTH MEETING

#### PART A. COMMITTEE BUSINESS

##### 1. GENERAL

- 1.1 Participants
- 1.2 Adoption of the final summary record of the sixteenth meeting
- 1.3 Adoption of the agenda
- 1.4 Completion of actions
- 1.5 Committee representation (Secretariat)

##### 2. OLD BUSINESS

- 2.1 Activities of US and NEA centres of interest to EACRP (Secretariat)
- 2.2 Requests from EANDC
- 2.3 Miscellaneous

##### 3. NEW BUSINESS

- 3.1 Organization of the eighteenth meeting: agenda, time, place, participants
- 3.2 EACRP observers at the next EANDC and "CREST" meetings
- 3.3 Election of Officers
- 3.4 Distribution and listing of documents

#### PART B. TECHNICAL SESSIONS

##### 1. GENERAL

- 1.1 Review of recent activities, national programmes, discrepancies, evaluation work (all members)
- 1.2 Report from the "CREST" meeting (Bussac)
- 1.3 Highlights from recent meetings of interest to EACRP:
  - Structural mechanics in reactor technology, Berlin, 10-14th July, 1973 (Küstners)
  - Third IAEA Symposium on Physics and Chemistry of Fission, Rochester, 13-17th August, 1973 (Hannum)
  - ANS topical meeting on irradiation experimentation on fast reactors, Jackson Lake, 10-12th September, 1973 (Loewenstein)

Consultants' meeting on cross-sections for in-pile dosimetry, Vienna, 10-12th Sept. 1973 (Farinelli)

Reactor heat transfer, Karlsruhe, 9-11th October 1973 (Küsters)

Physics of fast reactors, 16-23th Oct. 1973 (Hirota ...)

ANS national winter meeting, San Francisco, 11-16th November 1973 (Hannum)

IAEA Panel on Fission Product Nuclear Data, Bologna 26-30th November 1973 (Tyror)

IAEA Workshop on Fusion Reactors, Culham, 29th January - 15th February 1974 (Spano)

Fast reactor power stations, London, 11-14th March 1974

Gas-cooled reactors: HTGR and GCFBR, Gatlinburg, 8-10th May 1974 (Tyror, Maienschein)

- 1.4 Report on the seventeenth EANDC meeting (Hirota, Secretariat)
- 1.5 Compilations (Hannum, Farinelli, Casini, Secretariat)
- 1.6 Miscellaneous

## 2. INFORMATION ON MEETINGS RECOMMENDED BY EACRP

- 2.1 Specialists' meetings on
  - Resonance parameters for U238 and Pu239
  - Processing of nuclear data libraries
  - Monte Carlo
  - Reactor noise
  - Dynamic benchmark comparisons
- 2.2 NEA/IAEA meeting on
  - Methodology of sensitivity studies with regard to radiation transport and energy deposition

## 3. TOPICS CARRIED OVER FROM PREVIOUS MEETINGS

- 3.1 Detector cross-sections (Bussac, Farinelli, US)
- 3.2 Intercomparison of adjusted cross-section sets (Hirota ...)
- 3.3 Error files and error correlation (Farinelli, US, ...)

## 4. NEW TOPICS

- 4.1 Benchmark test cases (Bussac, US, ...)
  - (a) Definition and use of benchmarks
  - (b) Proposal for benchmarks with particular reference to shielding and  $\gamma$ -heating
- 4.2 Operational physics experiences from LMFBR:s (Bussac, UK, US)

- 4.3 Sodium void effects (Bussac, Küsters, Hirota, UK, US)
- 4.4 Cross section collapsing including adjoint fluxes (Farinelli, US, ...)
- 4.5 Target accuracies and the basis thereof for commercial-sized reactors (Bussac, Hirota, Küsters, UK, ...)

5. TUTORIAL SESSIONS

ANNEX 6

CLASS A DOCUMENTS RECLASSIFIED AT THE 16th EACRP MEETING

EACRP-A-180 reclassified as:

EACRP-L-94        The central worth discrepancy: by E.M. Bohn,  
1st June, 1972

EACRP-A-181 reclassified as:

EACRP-L-95        Some observations on the comparison of measured  
and calculated small sample reactivity worths  
of fissile isotopes in fast integral assemblies:  
by R.W. Smith, 28th June, 1972

EACRP-A-185 reclassified as:

EACRP-L-96        Fast reactor spectrum measurements and their  
application to data adjustment studies:  
by J.L. Rowlands and J.E. Sanders, June 1972

EACRP-A-186 reclassified as:

EACRP-L-97        Transplutonium elements in thermal reactors:  
by C.F. Griggs and M.J. Halsall, 27th June, 1972

EACRP-A-188 reclassified as:

EACRP-L-98        Prediction of void coefficients in fast and  
thermal reactors: by E.A. Fischer, P. Kilian  
and H. Küsters, June 1972

ANNEX 7

LIST OF DOCUMENTS DISCUSSED AT THE 16th MEETING

Class A

- EACRP-A-199 Progress in fast reactor physics in the Federal Republic of Germany: compiled by H Küsters
- EACRP-A-200 Sensitivity studies in shielding: by C Devillers
- EACRP-A-201 Error analysis of calculated neutron flux resulting from error in input nuclear data in case of iron shield: by H Yamakoshi
- EACRP-A-202 Provisional review of the EACRP 1D-dynamic benchmark problem: by H Küsters
- EACRP-A-203 Suggestion to measure the  $^{238}\text{U}$  capture cross-section in the thermal region: by J Basiuk, G Le Coq and P Reuss
- EACRP-A-204 Comparison of measured and calculated temperature coefficients: Douglas Point Reactor
- EACRP-A-205 Comparison between predicted and measured temperature coefficients of reactivity in some light water lattices (with annex): by G Andersson, M Edenius, E Hellstrand and R Persson
- EACRP-A-206 Formats and procedures for ENDF/B error files: by F G Perey, 30th May, 1973
- EACRP-A-207 Comparison among adjusted, unadjusted and differential data of cross-sections: by H Kuroi and J Hirota, May 1973
- EACRP-A-208 Calculation of neutron data adjustments based upon the ENDF/B-III library and upon discrepancies between measured and calculated integral data: by H Häggblom
- EACRP-A-209 Experimental and theoretical determination of  $\gamma$  and neutron energy deposition. Part A: Generalities, by C Devillers. Part B: Measurement of neutron and gamma power in reactors: by J L Campan
- EACRP-A-210 Theoretical and experimental determination of  $\gamma$  and neutron energy deposition:  
(a) Leidi: Ein Programm zur Aufschlüsselung der Leistung in einem Reaktor nach Stoffen und Prozessen: by C Faber, June 1971  
(b) Measurement of the  $\gamma$ -heating with RPL glasses: by H Doerfel and H Werle
- EACRP-A-211 Status report on the uranium-water lattice compilation, Part 2: by R Martinelli

- EACRP-A-212 NEA Computer Programme Library Activities of interest to the EACRP (May 1972 - April 1972)  
Annex I: A list of computer programmes for neutron cross-section calculations and analysis  
Annex II: SECU questionnaire
- EACRP-A-213 NEA/CCDN activities of interest to the EACRP (May 1972 - April 1973)
- EACRP-A-214 Report on CREST activities of interest to the EACRP

Class L

- EACRP-L-82 A comparison of reactivity scales in a fast critical assembly: by J E Sanders and J M Stevenson, June 1973
- EACRP-L-83 Space-Dependent Reactor Dynamics: by E Vincenti, G Forti, A Clusaz and S Dal Ben, April 29, 1973
- EACRP-L-84 (a)RADYVAR2-A two-dimensional accident analysis code for LMFBR with space dependent feedback: by D Struwe  
(b)The quasi-static approach KINTIC: by L Mayer  
(c)Fast Reactor Transient Analysis with Synthesis and few Group models: by W B Terney and R Srivenkatesan  
(d)Fully implicit matrix decomposition method for space-time kinetics: by A Birkhofer and W Werner
- EACRP-L-85 Studies of sensitivity of shield performance to nuclear data variations: by F C Maienschein, May 1973
- EACRP-L-86 Fast neutron transport in graphite, iron and sodium: by K Takeuchi and S Miyasaka
- EACRP-L-87 Specification of a generally useful multi-group structure for neutron transport: by C R Weisbin and R J LaBauve
- EACRP-L-88 The production and performance of the adjusted cross-section sets FGL5 and FD5: by C G Campbell and J L Rowlands, June 1973
- EACRP-L-89 Multi-group cross-sections evaluation at CNEN using integral data and statistical adjustment techniques: by A Gandini, M Petilli and M Salvatore
- EACRP-L-90 Analysis of energy deposition due to neutron and gamma rays: by Y Taji, S Miyasaka, J Hirota, S Inoue, T Ideta, T Asaoka and S Katsuragi, May 1973

- EACRP-L-91 Reactor physics activities in OECD countries:  
June 1972 - May 1973
- (a) Reactor physics activities in Austria: by F Putz
  - (b) Reactor physics activities in Canada: by M F Duret
  - (c) Recent reactor physics activities in Denmark:  
by B Micheelsen and H Neltrup
  - (d) Reactor physics at JRC - Euratom/Ispra:  
by G Casini
  - (e) Reactor physics activities in CEA France:  
by J Bussac  
Appendix 1: APOLLO: A general code for transport,  
slowing down, and thermalisation calculations in  
heterogeneous media (EACRP-U-50)  
Appendix 2: Fast reactor physics in France:  
by J Bussac and M Estavoyer (EACRP-U-51)
  - (f) Reactor physics activities in Germany: by H Küsters
  - (g) Summary of reactor physics activities in Italy:  
by U Farinelli
  - (h) Reactor physics activities in Japan; by J Hirota
  - (i) Reactor physics activities in the Netherlands:  
by M Bustraan
  - (j) Reactor physics activities in Norway: by J O Berg  
and S Børresen
  - (k) Reactor physics activities in Portugal: by  
J Costa Oliveira
  - (l) Reactor physics activities in Switzerland:  
by R Richmond
  - (m) Reactor physics in Spain; by R Ortiz Fornaguera
  - (n) Reactor physics activities in Sweden: by E Hellstrand
  - (o) Reactor physics activities in the United Kingdom:  
by C G Campbell and J G Tyror
  - (p) Reactor physics activities in the US: by W H Hannum,  
P B Hemmig, R J Neuhold, J W Lewellen and  
V W Lowery

EACRP-L-92 Comparison between predicted and measured temper-  
ature coefficients of reactivity in some light-  
water lattices: by G Andersson, M Edenius,  
E Hellstrand and R Persson

EACRP-L-93 Summary of finite element exchange: May 1973

Class U

- EACRP-U-47 A 3D benchmark problem: by B Micheelsen, 12th May, 1973
- EACRP-U-48 Recent discovery of a prehistoric nuclear reactor in  
République Gabonaise: by G Vendryes, November 1972
- EACRP-U-49 Thermal reactor temperature coefficient studies in  
the UK. by J R Askew, F J Fayers and W Fox, 1st June, 1973
- EACRP-U-50 APOLLO: a general code for transport, slowing down  
and thermalisation calculations in heterogeneius media:  
by A Kavenoky, April 1973
- EACRP-U-51 Fast reactor physics in France: by J Bussac and  
M Estavoyer

ADDITIONAL DOCUMENTS CONSIDERED DURING THE MEETING

- Lake Kiamesha
- Guidelines for the documentation of digital computer programmes: Standard ANS 10.3 Draft 8, 5th April, 1973
- Report on the 16th EANDC meeting (Paris, 1st-27th Dec., 1972): by M Bustraan
- HTR Physics at AEE Winfrith
- CP-5 research reactor (AUA Reports, 1973)
- Summary list of IAEA activities related to reactor physics
- EACRP-planned meetings of interest
- Some other main documents recently published by CEA
- A pragmatic approach to evaluated data files: May 1973
- Fast neutron processes in niobium; measurements and evaluation: by A B Smith, J F Whalen and P T Guenther AP/CTR/TM-4
- Activities of the IAEA in the reactor shielding field
- Meeting on capture data for structural materials: by H Küsters
- IAEA activity in reactor physics

## ANNEX 8

### IAEA ACTIVITIES RELATED TO REACTOR PHYSICS

(prepared for EACRP meeting, Chicago, 4-8th June 1973)

#### A. REACTORS

1. 3rd Symposium on "Physics and chemistry of fission", Rochester, 13-17th Aug. 1973
2. Symposium on "Experience from operating and fuelling of nuclear power plants", Vienna 8-12th Oct. 1973
3. Symposium on "Physics of fast reactors", Tokyo, 16-23th Oct. 1973 (in scientific cooperation with the IWGFR)
4. Panel on "Hot channel factor calculations (for LMFBR's)", Karlsruhe, 19-23th Nov. 1973 (sponsored by IWGFR)
5. "Workshop on "Fusion reactor design", Culham, 29th Jan. - 15th Febr. 1974
6. Conference on "Fast reactor power stations" (in scientific co-operation with the IWGFR), London, 11-14th March 1974
7. Joint OECD(NEA)/IAEA Symposium on "Gas-cooled reactors", 1974 (tentatively)

#### B. NUCLEAR DATA

1. Consultants' meeting on "Cross-sections for in-pile neutron dosimetry", Vienna, 10-12th Sept. 1973
2. International Nuclear Data Committee meeting, Vienna, 8-12th Oct. 1973
3. Panel on "Fission product nuclear data", Bologna, 26-30th Oct. 1973
4. Study Group on "Non-neutron nuclear data", 1974
5. Joint OECD(NEA)/IAEA Study Group on "Nuclear data requirements for shielding calculations", tentatively 1975
6. International Nuclear Data Conference, 1975

ANNEX 9

U. S. SHIELDING BENCHMARK EXPERIMENTS

Completed Reports

1. R. E. Maerker, "SDT1. Iron Broomstick Experiment - An Experimental Check of Neutron Total Cross Sections."
2. R. E. Maerker, "SDT2. Oxygen Broomstick Experiment - An Experimental Check of Neutron Total Cross Sections."
3. R. E. Maerker, "SDT3. Nitrogen Broomstick Experiment - An Experimental Check of Neutron Total Cross Sections."
4. R. E. Maerker, "SDT4. Sodium Broomstick Experiment - An Experimental Check of Neutron Total Cross Sections."
5. R. E. Maerker, "SDT5. Stainless-Steel Broomstick Experiment - An Experimental Check of Neutron Total Cross Sections."
6. R. E. Maerker, "SDT6. Experiment on Secondary Gamma-Ray Production Cross Sections Arising from Thermal-Neutron Capture in Iron, Stainless Steel, Oxygen, and Sodium."
7. R. E. Maerker, "SDT7. Experiment on Secondary Gamma-Ray Production Cross Sections Averaged Over a Fast-Neutron Spectrum for Iron, Stainless Steel, Oxygen, and Sodium."

Reports of Other Experiments which are in Various Stages of Preparation

ZPPR/FTR-2 Experiments

Neutron Attenuation Measurements in a Mock-up of the FFTF Radial Shield

ORNL Iron and Stainless Steel Benchmark Experiments

ORNL Sodium Benchmark Experiment

LLL Sphere Transmission Experiments

ANNEX 10a

EACRP PROPOSAL FOR A MONTE CARLO SPECIALISTS' MEETING

1. The Monte Carlo method has become a widely-used tool in dealing with reactor physics problems. EACRP invites specialists to discuss improved techniques which hold promise of more effective and reliable use of Monte Carlo methods in the areas of core physics, shielding and criticality studies.
2. Two or three user experts should be invited to review the state of the art of Monte Carlo application in these areas, and to identify problems for which new techniques appear to be required.
3. The EACRP does not wish to consider the application of well-established Monte Carlo methods but rather to encourage contributions on improved techniques such as:
  - improved variance reduction, variance estimation and convergence acceleration schemes in assigned source and eigenvalue calculations
  - improved geometry packages and cross section handling techniques
  - adjoint Monte Carlo schemes
  - calculation of reaction rates at points or in small portions of phase space
  - improved perturbation techniques, especially for small portions of phase spaceOther improved or newly-developed techniques should not be excluded.
4. The meeting should be limited to about 20 experts in order to permit free and effective discussions.
5. A summary report of the meeting should be prepared and forwarded to EACRP.

ANNEX 10b

SPECIALISTS' MEETING ON REACTOR NOISE

OBJECTIVES

The meeting should:

- Evaluate the state of the art in low power reactor noise and draw conclusions on theory, interpretation, applicability and effectiveness of noise techniques in determining reactor parameters.
- Identify the major open problems and the possible developments that might deserve pursuing, at least in an academic environment.
- Review areas of prospective interest for the application of noise measurements in power reactors and consider their implication on power reactor instrumentation.
- Discuss the theory of noise measurements in power reactors and consider the applicability or possible extension of methods and concepts developed for zero-power systems.
- Help in shaping the programmes in this field (in most countries, just at the initial stage) so as to increase co-operation, reduce duplication and pursue effectiveness.
- Review existing measurements and available information from power reactors.

