NEANDC 114"L"

S U M M A R Y   R E C O R D

of the

TWENTIETH MEETING

(Technical Sessions)

Oak Ridge, U.S.A.

3-7 April,1978

Compiled by C. Coceva (Scientific Secretary)

NUCLEAR ENERGY AGENCY NUCLEAR DATA COMMITTEE

TABLE OF CONTENTS

LIST OF PARTICIPANTS

a) Committee Members

1. I. Bergqvist (replacing H. Condé), Sweden
2. R.E. Chrien, US, Chairman
3. S.W. Cierjacks, Germany
4. C. Coceva, Italy
5. W.G. Cross, Canada
6. E. Fort, France
7. P. Johnston (replacing N. Tubbs), NEA, Secretary
8. H. Liskien (replacing K.H. Böckhoff), Euratom
9. F. Maienschein, US, CRP Observer
10. A. Michaudon, France
11. H.T. Motz, US
12. F.G.J. Perey (replacing H. Jackson), US, Local Secretary
13. S.M. Qaim, Germany
14. J.L. Rowlands (replacing J. Story), UK
15. M.G. Sowerby, UK
16. K. Tsukada, Japan
17. N. Tubbs (replacing J. Rosen), NEA
18. H. Vonach (replacing O.J. Eder), Austria
19. S. Whetstone (replacing G. Rogosa), US

b) Observers

1. D.E. Bartine, ORNL
2. R.C. Block, RPI
3. C.D. Bowman, NBS
4. J.L. Burnett, DOE
5. G. de Saussure, ORNL
6. J.K. Dickens, ORNL
7. D.M. Drake, LASL
8. W.B. Ewbank, ORNL
9. C.Y. Fu, ORNL
10. R. Gwin, ORNL
11. J.A. Harvey, ORNL
12. D.J. Horen, ORNL
13. E.H. Kobisk, ORNL

14. D.C. Larson, ORNL
15. B.R. Leonard, BNW
16. R.L. Macklin, ORNL
17. F. Maienschein, ORNL
18. E. Newman, ORNL
19. E.M. Oblow, ORNL
20. C.L. Ottinger, ORNL
21. S. Pearlstein, BNL
22. R.W. Peelle, ORNL
23. S. Raman, ORNL
24. J.S. Schweitzer, Schlumberger-Doll Research Center
25. A.B. Smith, ANL
26. R.R. Spencer, ORNL
27. C.R. Weisbin, ORNL
28. L.W. Weston, ORNL

I. Opening

After the opening of the meeting by the chairman, committee members are welcomed by A. Zucker, ORNL director, who gives also a brief description of the main facilities, among which the new 25 MV recycled Van de Graaff, and illustrates the new and continuing areas of interest investigated at ORNL.

The local secretary announces the absence of J. Smith, IAEA observer; some questions concerning IAEA may be dealt with by H. Vonach.

Apologies for absence have been received from Bockhoff; in his place Euratom representation will be assured by H. Liskien who will be able to join the meeting during the afternoon session of Tuesday, April 4th.

II. National Progress Reports

1 Summaries

Progress reports in written form are presented from Germany, U.S., Japan, Canada, Austria and Euratom (appendix 15). No summary is presented orally; only new and planned facilities are presented (following item).

2 Facilities, New and Planned

U.S.A. Motz describes the new pulsed neutron facility WNR, obtained from an 800 MeV proton beam at LAMPF, and the planned performance of the storage ring.

Peelle describes the plans to upgrade ORELA with a new bunching system which should increase the beam current by a factor 3-4.

Smith informs about the status of the ANL superconducting linac to be used to boost the energy of heavy ions from the FN tandem.

Bowman relates on a proposed Very Intense Radiation Facility being considered at NBS as a possible replacement of the electron linac. This would be an induction linac capable of accelerating up to 36 MeV electron pulses 5 to 60 nsec wide with 2000 A peak current at a repetition rate of 180 pps. Due to the independent phasing of each section, it could also accelerate protons, deuterons and heavier ions. A storage ring could also be added to obtain a 100% duty cycle beam.

U.K. Sowerby gives a brief description of the new electron linac at Harwell (see Kiev Conference, 1977).

The synchrocyclotron at Harwell will probably be closed.
The spallation neutron source at the 7 GeV accelerator at Rutherford Lab. is replaced by a target system for solid state studies.
An intense pulsed neutron source is planned using the 800 MeV cyclotron, to obtain a yield of 4.10^{16} n/sec with 0.4 μsec pulses.
Germany. Cierjacks gives the characteristics of the improved isochronous cyclotron at Karlsruhe, which now can deliver pulses of 0.6 nsec with a mean current corresponding to 40 μA at 200 kHz repetition rate. He reports also on studies for an intense neutron source, to be obtained presumably from a linear accelerator and the d+Li reaction, designed for research work on data for controlled nuclear fusion programs. The work of the three cyclotrons at Jülich, Essen and Braunschweig is mentioned by Qaim (see NEANDC(E)192 U vol.V).

III. Advances in Measurements and Evaluations

1 Scattering

Short reports are presented on the following works:

a) Fast neutron scattering cross-sections at Bruyères-le-Châtel (see NEANDC(E)194 L).
b) Fe-56 scattering cross section measurements at Karlsruhe.
c) Resonance scattering work at ORELA to assign spin and parity from angular distribution.

Perey says that interference between s-wave resonance and p-wave phase shifts cause relatively large angular distribution effects in neutron scattering; these might have some importance in shielding.
A. Smith points out the large discrepancies shown by benchmark calculations of transport cross sections in Fe.

2 Fission Neutron Spectra

Michaudon reports on fission neutron spectra measurements performed at Bruyères-le-Châtel (see NEANDC(E)193 L).
Perey evokes the problem of error correlations, with particular reference to Cf-252 and U-235.

3 Fission Cross-Sections

A Smith comments on the σ_f(U-235)/σ_f(U-238) discrepancy in the MeV region. The measurement of fission cross section of Th-232 at ANL gave values consistently lower than ENDF/B IV data in the MeV region, while, for U-233, measured values are higher.
Measurements performed at Karlsruhe on U-235, Pu-239 and Pu-240 in the 1-20 MeV region are reported by Cierjacks (see NEANDC(E)192 U,vol.V).

4 Fission Product Nuclear Data

Sowerby presents the progress report on chemical nuclear data NEANDC(UK)172 A containing all recent measurement and evaluation work on FP performed in the UK.
Fort summarizes the FP cross section evaluation work carried out under the joint Italian-French program. Integral experiments showed discrepancies with the evaluated data of Nd-143, Ag-109 and Sm-151; evaluation of these nuclei will be repeated.
Qaim outlines briefly the continuing work on the half-lives of FP performed at Jülich with the mass separator JOSEF.
No oral presentation of the U.S. work is given due to the absence of C. Reich.

5 $\bar{\nu}$ of Cf-252

The measurement performed at Oak Ridge is described by Spencer. A 900 ℓ Gd poisoned liquid scintillator tank was employed; corrections were made to take into account efficiency variations with angle of emission and energy of neutrons.

IV. International Developments in Nuclear Data Measurements, Compilations and Evaluations

1 A Chain Evaluation

Pearlstein and Ewbank outline the current status of international cooperation and the rôle of the Nuclear Structure and Decay Data Network of IAEA. Efforts are made to organize a four-year update cycle for the Table of Isotopes and the Nuclear Data Sheets.
The U.S. organization, type of data, formats,etc..of the Evaluated Nuclear Structure Data File (ENSDF) are discussed, and the centralized coordination rôle of the National Nuclear Data Center at BNL and of the Nuclear Data Project at ORNL is elucidated.
The Committee asks for a written report describing the ENSDF.

2 NNDC/CSEWG

Pearlstein describes tasks and composition of the Cross Section Evaluation Working Group, who is charged of the evaluation of neutron data and the maintenence of the ENDF/B file. In addition to the General Purpose Library, Pearlstein mentions some Special Purpose Files, such as the Actinide file, which is planned for completion at the end of 1978.
As summarized by Michaudon at the end of the discussion, 1) the Committee asks to be informed on the schedule of each new version of ENDF/B, 2) Cooperation with non-US evaluation groups is possible, provided that they conform with the characteristics of ENDF/B (complete information base, documented, integrated into methodology, application independent); 3) It is suggested that non-U.S. evaluators could attend CSWEG meetings.
All forms of cooperations in this area will be coordinated by Pearlstein.

3 Separated Isotopes, Samples

After introduction by E. Newman, J.L. Burnett illustrates the isotope loan and sales program.
The following information is obtained on questions raised by the Committee:

a) In general it is not possible to obtain credit upon return of purchased samples.
b) Cost is always calculated at time of shipment; any payment in advance is taken as a deposit.
c) Chemical purification of actinides during loan period is allowed, but losses must be payed.
d) The question of shipment by air of Pu isotopes is not solved in general; one must obtain a special dispensation, case by case.

E. Newman gives a description of isotope separators in use. Future separation plans can in principle be influenced also by non-U.S. needs, provided they are known very much in advance; anyway it is also a question of cost.
C. Ottinger makes a review of isotope distribution programs, and explains the rules for purchase of isotopes and services, and for

contracts and procurement of loans from the research material collection . In the discussion of some questions raised by the Committee, the following information is obtained:

a) Pu isotopes fall under NPT . Guidelines for procurement of Pu isotopes to non-U.S. users will probably be available within 2 or 3 months.

b) The master agreement with Euratom is still valid up to the end of the year.

c) Separated isotope production level, which is determined by foreseen revenue, may be higher: if there were a demand, the operation could be expanded, but the cost may be extremely high.

E. Kobisk reviews the inventory forms, services, possibilities of converting the materials in different forms, such as metals, alloys, ceramics, reactor dosimetry materials, track recorder deposits, standard reference fission foils, etc.,

4 Flux Intercomparison

Bowman describes the U.S. programmes, as reported at the Normalization and Standards Subcommittee of CSEWG, and summarizes the results of the International Specialists Symposium on Neutron Standards and Applications. Standard flux intercomparison at 14 MeV, 2.5 MeV and 250 keV shows a spread approximately as large as the quoted uncertainty. A new international programme of intercomparison of the measured neutron emission rate of a circulating Cf-252 source will be started within 2-3 months.

For a new international intercomparison of 14 MeV neutron sources, studies are being made about transfer methods.

An ANL/NBS intercomparison of fission foils, used as secondary standard for fast neutron fluence measurements, gave agreement within 1%.

5 Half-Lives

In the discussion on standard half-lives, needed for foil assaying and reactor burn-up measurements, A. Smith says that highly accurate determinations are needed for all U isotopes, Pu-241, Cm-242, Pu-242. Smith reports also on alpha decay measurements performed at Argonne on Pu-238, Pu-239, Pu-240, Pu-242 and Cm-242.

V. New and Continuing Nuclear Data Needs

1 Cross Sections for High Energy Neutron Damage Sources

A. Smith reports on the 10-40 MeV Neutron Cross Section Symposium held in Brookhaven (see NEANDC(US)202 L) and reviews the projects for irradiation test neutron sources in the frame of research on materials for fusion technology.
The need is stressed for an integral test facility for dosimetry in fusion reactor work. A brief description is given of the proposed Fusion Materials Irradiation Test facility (FMIT) to be located at the Hanford Lab., which should provide a continuous output of $2x10^{16}$ high-energy neutrons per second.
Nuclear data, specially neutron dosimetry reactions, necessary for characterization of the neutron spectrum and fluence of FMIT are reviewed.
The inadequacy of current knowledge of the inelastic neutron scattering cross sections in shielding problems of these neutron sources is pointed out by B. Leonard.

2 Cross Sections of Gas Producing Reactions

Qaim underlines the importance of detailed investigations on nuclear reactions leading to the production of Hydrogen and Helium in structural materials. Most important at 14 MeV are (n,p) and (n,α) reactions, but it has been demonstrated that reactions like (n,n'p) and (n,n'α) can contribute appreciably, and should deserve extensive study. Currently only two groups, at Livermore and Jülich, are engaged in this type of work: it is advisable to increase the efforts in this direction. It is suggested to extend the LLL solenoid method, and to study the (n,α) reaction in the N-14 contaminant in stainless steel.

3 Fusion Data Needs

Motz notes the unsatisfactory knowledge of fusion reaction cross sections below 100 keV; the contribution of the tail of the maxwellian distribution of projectile velocities in this low-energy region has an appreciable importance. Work performed on $T(t,2n)^4He$, $D(t,n)^4He$ and $D(d,n)^3He$ at Los Alamos is illustrated.
A better knowledge is needed also of the T+t cross section for diagnosis of plasma conditions. In the discussion, Liskien points out the importance of reaction cross sections for d nuclei recoiling in the blanket material of fusion reactors.

Integral experiments on fusion blanket materials, performed with 14 MeV neutrons and threshold detectors or proton recoil or time-of-flight spectrometers showed large discrepancies with calculated data.

4 Cross Sections for the Thorium Fuel Cycle

D. Bartine reviews current problems concerning the Thorium cycle. Since breeding ratios, both for thermal and fast breeders, are estimated to be very low, i.e. around 1.05, it is necessary to reach a high precision in the evaluation of Th and U-233 data, all the more so as one has to take into account losses in fuel recycle (2% minimum). Great importance is given to the capture cross section of Th-232 through which U-233 is produced after decay of the 27½ days Pa-233.
Other breeding concepts being considered are:

a) Use of Pu-U as driving fuel and Th as blanket,
b) Use of accelerators to produce high energy particles (see Proceedings of an Information Meeting on Accelerator Breeding, 1977, CONF-770107).

Problems in fuel reprocessing are given by the presence of highly penetrating 2.6 MeV gamma rays from the decay of Tl-208.
Important cross sections to be studied are $^{232}Th(n,2n)$, $^{233}U(n,2n)$ $^{233}Pa(n,2n)$ $^{230}Th(n,\gamma)$.
It is noted that Th-230 content depends on the source of Th ores.
Measurements related to the criticality (fission, capture and $\bar{\nu}$) for U-233 are obviously of great interest.
Moreover, in fast reactors, fission rate in Th-232 will be a factor 3-4 lower than in U-238 for U-Pu breeders, resulting in higher requirements on the fissile isotope.
Bowman points out that Th-232 purity requirements are 100 times less stringent in thermal than in fast breeders. He also underlines the possible importance of D_2O photoneutron cross section in thermal breeders.
Cross describes the investigations performed in Canada on fission cross sections of U-233, and capture cross section of U-233 and Th-232 at thermal energies.
Rowlands notes that employing U-233 in fast reactors would reduce the Sodium void effect.

C. Weisbin describes the activity of CSWEG for cross sections relevant to the Thorium cycle,and distributes a memorandum from M. Bhat on Th-232 capture cross section evaluation for ENDF/B V.
R. Block reviews the status of measurements of Th cross sections at low energy. In particular the value of the fission cross section at thermal energy obtained at RPI, 54 μb , is much higher than the corresponding value obtained at Grenoble.
Block describes also the use of the slowing down lead spectrometer at RPI to measure the breeding ratio for U-233 fuel elements from Shippingport.
Threshold detectors are used to determine the amount of U-233 in spent fuel elements.

5 Cross Section Measurements for the Actinides

S. Raman summarizes the work completed or planned at ORNL. In particular, Th, U, Np and Pu samples were irradiated with a total dose of 10^{23} neutrons; the build-up of actinides was analysed and compared with calculations performed with the ORIGEN program.
Recommendations of the 1975 Karlsruhe meeting are brought to the attention of the Committee. On their basis, the first Actinide Newsletter was edited by Raman (the second will be issued in November 1978), and IAEA is coordinating international efforts of measurements and evaluations.
S. Raman mentions also a cooperation work between U.S. and U.K. on integral experiments, the work at NBS on the fission cross section of Np-237 and Am-243, and the measurements at RPI on a 4 μg sample of Cm-245 with the lead slowing down spectrometer.
It is reminded that the work performed at Harwell on this subject can be found in the proceedings of the Kiev Conference.

6 Decay Heat

Motz summarizes measurements and calculations performed at Los Alamos, and describes plans of the ANS 5.1 Committee to derive a new decay heat standard for U-235. Results are presented also for Pu-239 and U-233. The 20% difference in decay heat between U and Pu given by the ANS standard is not confirmed by experiment, giving only a 10% difference.
K. Dickens presents the results of several experiments compared with calculations based on ENDF/B-IV data, for decay heat from γ - and

β-rays. In general, calculated and experimental data show different time behaviours, but only in the case of Pu measured γ-ray heat is always higher than calculated from ENDF/B IV.
Measurements and calculations performed at Winfrith on Pu-239 and U-235 are presented by Rowlands, who points out discrepancies of about 10% between experimental and calculated data in Pu, and a similar discrepancy in U-235 for times larger than 10^4 sec.
It is reminded that according to the decision taken at the Petten Conference, all results obtained in the OECD area concerning decay heat from fission products should be given to K. Dickens.
As a conclusion, Dickens recommends the following measurements of decay heat:

i) from fast neutron fission in U-238
ii) from Pu-241 in thermal reactors; this is specially important in case of a partial enrichment process of spent fuel rods.
iii) Measurements at short time need to be improved (starting about 5 seconds after shutdown)since current data show systematic deviations from calculated values.

7 Shielding for LMFBR

Maienschein summarizes the results presented at the New York meeting of the ANS. Important materials are Sodium and the major constituents of Inconel, mild and stainless steel: iron, chromium and nickel. The situation is illustrated by the results of an integral measurement performed with a shield composed of approximately 1.1 m of steel and 4.6 m of Na, which gave a deviation of experimental vs. calculated data by a factor 3. Since, for such attenuations, deviations by a factor 2 are considered satisfactory, the situation is not far from being under control.
Rowlands says that by November 1979 a request list for microscopic data measurements, with accuracy requirements, should be ready. Calculation studies of specific reactor designs and benchmark experiments are planned in the U.K. for the definition of nuclear data needs. A preliminary version of this request list should be ready for the next NEANDC meeting.

8 Biomedical Applications

Qaim reviews questions concerning short lived γ-emitters in the range 60-600 keV. Data needs are mainly excitation functions for isotope production with cyclotrons; for instance (d,xn) cross sections of Br and Kr . Calculation of these cross sections would probably require the inclusion of precompound effects. With the scope of obtaining a definition of the needs in this field, the Committee asks Pearlstein to supply a list of compilations and references to radio-isotope production. Similarly, Qaim is asked to produce a list of nuclear data needs in this field.

About neutron produced radio-isotopes, Cross, reporting the conclusions of the ICRM committee, says that all needs may amount to six half-lives and two or three decay schemes. Little information is needed on β-decay branching.

Concerning data for neutron therapy, two documents are available from AAEC Canada. Data needs concern mainly the production of neutrons: angular distributions and yields of the low-energy end of the spectrum.

Cross section requirements for activation dosimeters and for shielding can probably be managed by calculation.

VI. Meetings

1 NEANDC/NEACRP Specialist Meeting on Neutron Data of Structural Materials in Fast Reactors

An information paper on this meeting, held in Geel 5-8 December 1977, was distributed by Böckhoff (NEANDC(E)197A).

Concerning capture cross sections for structural materials in the A=50 and A=100 regions, there seems to be no obstacle in performing measurements with the desired accuracy, provided that enriched samples are available. An example of such possibility is given by the recent measurements on Cr.

Perey stresses the fact that resonance analysis with Breit-Wigner single level formula is not adequate in this region. Also separate determinations of g and Γ_n are necessary.

Block adds some information on unpublished data about Fe-56 minima, obtained at Brookhaven. The importance of investigations on the effects of non-isotropic neutron angular distribution in multiple scattering corrections and self-screening is stressed.

Smith points out that in view of obtaining an uncertainty below 3% in the breeding factor, a list of the corresponding accuracies in structural materials cross sections is needed.

2 Fission Product Nuclear Data, Petten, 1977

Proceedings of this meeting have already been issued.

Fort stresses some important items:

- Capture cross sections of Xe-155 and Sm-149 with 10% accuracy are needed.
- Discrepancy in resonance integral of Pd-107
- For burn-up calculations, cross-sections for the bulk of F.P. are required in the fast region
- New measurements are recommended for Tc-99, Ru-102, Ru-104, Pd-105, I-127, Pm-147, Sm-151.
- A specialist meeting is recommended on the techniques to evaluate average spacings from experimental data.
- Rh-103 is suggested as standard for integral measurements.
- Recommendation to national nuclear data committees concerning nuclear data request lists.

3 LMFBR Benchmark Exercise, Argonne, February 1978

Within 10 submissions, the differences in the predicted k_{eff} amounted to $\approx$ 3%; use of UKNDL and Carnaval IV led to a 0.9% difference. Different calculations based on ENDF-B/IV were consistent within 1%.

As far as Sodium void effect and Doppler effect are concerned, 10% differences were obtained.

It is noted that ENDF-B/IV overestimates the ratio σ_c(U-238)/σ_f(Pu-239) by 1.5%.

The sensitivity to the input data of the flux ratio in the two zones of the LMFBR gave rise to 10% differences. Also the predicted reactivity worths of the central control rod were very different.

The general opinion is that the 3% differences obtained in reactivity calculations are mostly due to differences in the input data.

The differences between calculations based on ENDF/B-IV and U.K. files are substantially influenced by the Chromium capture cross sections used.

VII. Standards and Discrepancies

1. Normalization and Standards Subcommittee of CSEWG

B. Leonard, who is the chairman of this subcommittee, explains its organization to keep evaluated status files of standard nuclear data and discrepancies. Each important data area is entrusted to a laboratory or individual evaluator who establishes his procedures to select and evaluate the relevant results. Discrepancies are notified to the responsible laboratory or individual by CSWEG evaluators. Leonard stresses the paramount importance in the standard system of the primary high-energy standard, i.e. the neutron scattering cross section on Hydrogen, as well as the neutron reaction cross sections of Li-6, B-10, the fission cross section of U-235 and the capture cross section of Au-198.

Standard data are released to IAEA on the basis of an official agreement.
In the discussion following Leonard's presentation, Perey underlines the advantages of having standard data published in the open literature.

VIII. Topical Conference and Visit

On Wednesday morning, April 5, a topical conference is held on Techniques of Capture Cross Section Measurements.

In the afternoon of the same day, the Committee members could visit some experimental facilities at ORNL.