International Atomic Energy Agency

INDC(NDS)-231/L+R

INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

NUCLEAR DATA FOR RADIATION DAMAGE ASSESSMENT AND RELATED SAFETY ASPECTS

SUMMARY REPORT

Advisory Group Meeting
organized by the International Atomic Energy Agency
Vienna, 19-22 September 1989

Prepared by

N.P. Kocherov
IAEA Nuclear Data Section

December 1989

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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ABSTRACT

The IAEA Advisory Group Meeting on Nuclear Data for Radiation Damage Assessment and Related Safety Aspects was held at the IAEA Headquarters in Vienna, 19-22 September 1989. This report contains the conclusions and recommendations of this meeting.

The papers which the participants prepared for and presented at the meeting will be published as an IAEA Technical Document.

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CONTENTS

Conclusions and recommendations

INTRODUCTION

Radiation damage in materials is a field of increasing importance because the number of reactor service years is growing very fast. There were 429 nuclear power units working in the world as of July 1989. Despite the absence of new orders in the US and the after-Chernobyl slow down of atomic power reactor construction in the USSR the overall number of reactor units in the world is still growing and the total number of reactor operation years grows now by more than 1 year a day. It means that more and more reactor units (or their components) come to the end of their design service life and the problems connected with their exchange or extension of the service life become more and more important.

The Nuclear Data Section of the IAEA has been involved in the field of nuclear data for radiation damage assessment for about twenty years. Its programme on reactor neutron dosimetry resulted in the creation of the International Reactor Dosimetry File (IRDF) in 1982. This file is being updated constantly by NDS, the last version is now IRDF-85 and the creation of the next version is underway. Another activity of the NDS in this field is the international intercomparison exercise REAL, several rounds of the exercise were run and the results of these activities were discussed by the participants at the meeting.

The first Advisory Group Meeting on Nuclear Data for Radiation Damage Assessment and related Safety Aspects was convened by NDS eight years ago in October 1981. The present meeting was a second one on this topic and it was intended to summarize the progress and status of nuclear data for radiation damage assessment since the first meeting.

The participants have emphasized that since the first meeting a number of spallation neutron sources were put into operation and many material radiation damage studies are conducted now at these facilities. The distinguishing feature of spallation neutron sources is that the neutron energy spectra which they produce in most cases have a high energy component which may give a significant contribution to radiation damage. The proper understanding of radiation damage experiments in these neutron fields requires a better knowledge of nuclear data at high neutron energies.

These ideas were formulated in detail in the conclusions and recommendations of the participants which are contained in this report.

Another new issue was the need for activation cross-section data of long-lived isotopes. This topic is also considered in the conclusions below.

List of Presentations by Participants

IAEA Advisory Group Meeting on NUCLEAR DATA FOR RADIATION DAMAGE ASSESSMENT

Vienna, 19-22 September 1989

1. B. OSMERA
"Survey of Experimental and Theoretical Studies for WWER Pressure Vessel Neutron Exposure Evaluation in LR-0 Experimental Reactor"
2. F. HEGEDUES
"Medium Energy Dosimetry"
3. E. ZSOLNAY, H.J. NOLTHENIUS, E. SZONDI
"The Role of the REAL-88 Exercise in the Radiation Damage Characterization of Nuclear Facilities"
4. L.R. GREENWOOD
"Radiation Damage Calculations for Compound Materials"
5. F.J. RUDDY
"Solid State Track Recorder Pressure Vessel Surveillance Neutron Dosimetry at Commercial Nuclear Power Reactors," F.H. Ruddy (W R&D) and J.G. Seidel (W R&D)
6. "Benchmark Referencing of Ultra Low-Mass Solid State Track Recorder Neutron Dosimetries in NBS Standard Neutron Fields," F.H. Ruddy (W R&D) and E.D. McGarry (NBS)
7. R. DIERCKX, V. SANGIUST
"Nuclear Data Needs in High Energy Neutron Dosimetry and Radiation Damage"
8. E. SZONDI, A.P. BOSNAI
"Physically Based Weighing Spectrum Generation for Cross-Section Calculations"
9. N.P. KOCHEROV et al
"Neutron Activation Dosimetry in Experiments with Massive Targets Irradiated with 1GeV Protons"
10. K.I. ZOLOTAREV, A.B. PASHCHENKO, V.G. PRONYAEV
"Results of CJD Calculations of REAL-88 Research Programme"
11. A.I. RYAZANOV, V.A. BORODIN, M.V. MANICHEV (I.V. Kurchatov Institute of Atomic Energy)
"The Effects of Nuclear Transmutations Under Neutron Irradiation on Mechanical Properties of Reactor Structural Materials"
12. V.V. GAN
"Problems of Damage Dose Calculations for Multicomponent Materials" (Item for round table discussion)
13. S. CIERJACKS
"Nuclear Data Needs for Low-Activation Fusion Materials Development"
14. L.R. GREENWOOD
"Measurement at Long-Lived Isotopesand Helium Production in Fusion Materials"

CONCLUSIONS AND RECOMMENDATIONS

Workshop 1

Chairman: S. Cierjacks

Nuclear and Atomic Data for Radiation Damage Calculations and Helium and Other Transmutation Product Cross Section Determinations in High-energy Neutron Fields

1. The working group recognized that radiation damage by atomic displacements and the generation of helium and other transmutation products will represent a severe problem in future fusion reactors. The search for appropriate materials requires high-intensity neutron sources which most closely simulate the high-energy spectra and the other irradiation conditions in the various fusion reactor components (especially the first wall). For this purpose, 14 MeV, t-hydrogen d-lithium and spallation sources have been proposed (see IFMIF Meeting, San Diego, February 1989). From these the latter two sources produce continuous spectra with an average neutron energy close to 14 MeV and a significant portion of neutrons in a high-energy tail (up to ~50 MeV for d-lithium and up to ~1 GeV for spallation sources). In contrast to the other proposed high-energy sources, spallation sources are presently in operation (e.g., LANSCE, LANL, US; IPNS, ANL, US; KENS, KEK, Japan; ISIS, RAL, UK) or under construction (SINQ, PSI, Switzerland). Although not yet giving the ultimately requested intensity for radiation damage studies, these sources continue to rapidly develop, driven mainly by solid and liquid state physics.

2. Independent of whether d-lithium or spallation sources will ultimately be used for large-scale radiation damage studies for fusion reactor materials or not, the generation of atomic displacements, helium, and heavier transmutation products must now be studied at greatly extended energies up to 1 GeV, in order to judge the suitability of these sources for fusion-materials radiation damage studies.

3. While being aware of, and supporting, the conclusions and recommendations on radiation damage and damage correlation estimates from the 1981 IAEA Advisory Group Meeting on Nuclear Data for Radiation Damage Assessment and Safety Aspects, the group

concentrated discussions on the aspects of neutron fields with largely extended neutron energies.

4. Concerning helium and higher transmutation product cross section measurements the following recommendations are made.

   a) The IAEA should compile and disseminate the existing high-energy cross section data for helium production and neutron monitor reactions as discussed at the present meeting (Appendices I.1-I.3). It is recommended to extend the range of data up to 1 GeV. Requests have been made that the Bologna, KFA and ANL groups investigate the possibility of extended model calculations for some of the most suitable monitor reactions.

   b) It is recommended that the IAEA stimulate an evaluation of the two proton monitor reactions $^{12}C(p,3p3n)^{7}Be$ and $^{27}Al(p,3p3n)^{22}Na$. Other reactions such as $^{56}Fe(p,n)^{56}Co$ and $^{65}Cu(p,n)^{65}Zn$ are considered to represent an important means to deal with mixed high-energy neutron-proton fields, typical especially for spallation sources.

   c) Many measurements of the present activation reactions leading to long-lived activities of interest in fusion radioactivity calculations are limited in accuracy due to large uncertainties in the half-lives and decay data of the product nuclides. Therefore, it is recommended that the IAEA stimulate a reexamination of these data for a broad range of applications.

   d) The present status of the data on production of transmutation products other than H and He should be improved. It is recommended to gather existing measurements and to foster comparisons with calculations from suitable high-energy nucleon-meson transport codes. In addition to the existing results (for example, from CEC), new experiments are recommended. In this case, thin target measurements are proposed in order to avoid large spectra uncertainties due to the strong depth dependence in thick targets.

e) The inconsistencies experienced in the Ispra work presented at this meeting suggest that tests of the most important monitor reactions are necessary. Such tests should be carried out with well-defined spectra from time-of-flight measurements, and widely varying spectra, with maximum energies ranging between ~100 and 1000 MeV, should be used.

5. Radiation damage cross section calculations have been discussed with the following conclusions:

a) It is recommended to measure "effective" displacement threshold energies for atoms in compound materials.

b) It appeared highly desirable to find suitable experiments for comparison with basic radiation damage calculations, relating the basic quantities such as Frenkel pairs, etc., to the "macroscopic damage effects" such as radiation-induced hardening, electrical resistivity, etc.

c) Radiation damage cross sections should be made available over the entire energy range from ~1 keV to 1 GeV for one or more recommended materials (e.g., iron and/or copper). Presently there is, however, a discontinuity in the overlapping range, for example, of low energy calculations with SPECTER and high-energy calculations with VNMTC. More theoretical work is recommended to match the two branches suitably in the overlapping range.

d) In addition to the damage due to He released in nuclear reactions, further damage is produced by transmutation products. The basic data needed for a theoretical calculation of this type of damage are the microscopic transmutation production cross-sections and recoil energy spectra. It appears desirable to develop a simple model of damage energy partitioning for the components of alloys and compounds (for example, steel). It is recommended that IAEA provides the users with information on available methods (computer codes) for the calculation of these quantities and, as far as possible, to collect the above mentioned data and to create a compilation in a standard form (e.g., ENDF-6 format).

6. Nuclear data needed in activation calculations for fusion reactors have been brought to the attention of the group:

   a) The large majority of data needs is taken care of by a number of international efforts.

   b) The IAEA should, however, encourage all Member States to contribute to the improvement of the data for the ~250 important neutron-induced reactions listed by the UK group at Harwell (Appendix II).

   c) The IAEA should make available its expertise in charged-particle reactions and assist in the compilation and dissemination of (x,n) reaction cross sections needed for future more complete activation calculations.

Activation Reactions Used in High Energy Neutron Dosimetry

(for spallation sources)

F. Hegedues
Institut Paul Scherrer
CH-5232 Villigen, Switzerland

^{27}Al(n,x)^{22}Na, ^{24}Na, ^{7}Be

Sc(n,x)^{44}Sc, ^{42}K

Ti(n,x)^{46}Sc, ^{47}Sc, ^{48}Sc

Fe(n,x)^{51}Cr, ^{54}Fe, ^{56}Fe

^{59}Co(n,x)^{57}Co, ^{58}Co, ^{59}Fe

Ni(n,x)^{58}Co, ^{60}Co, ^{57}Ni

Cu(n,x)^{44}Sc, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{48}V,
^{51}Cr, ^{52}Mn, ^{54}Mn, ^{56}Co, ^{57}Co

Xr(n,x)^{89}Zr

^{93}Nb(n,x)Nb

^{115}In(n,n')^{115}I

Tm(n,x)^{147}Tm, ^{168}Tm

Au(n,x)^{195}Au, ^{196}Au

Fe(n,x)dp (1)

Fe(n,x) dp (2)

Fe(n,x)He (3)

Appendix I.2

Activation Reactions Used in High Energy Neutron Dosimetry
(for spallation sources)

L.R. Greenwood
Argonne National Laboratory
Argonne, Illinois 60439, USA

^{27}AL(n,x)^{22}Na, ^{24}Na, ^{7}Be
Fe(n,x)^{51}Cr, ^{52}Mn, ^{54}Mn
^{59}Co(n,x)^{52}Mn, ^{54}Mn, ^{56}Mn
Ti(n,x)^{46}Sc, ^{47}Sc, ^{48}Sc, ^{48}V, ^{44}Sc
Ni(n,x)^{57}Co, ^{58}Co, ^{57}Ni, ^{56}Co, ^{52}Mn, ^{54}Mn
Cu(n,x)^{48}V, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{56}Co, ^{57}Co, ^{58}Co, ^{52}Mn, ^{54}Mn
^{65}Cu(p,x)^{65}Zn
^{56}Fe(p,x)^{56}Co

Activation Reactions Used in High Energy Neutron Dosimetry

R. Dierckx
European Communities, JRC Ispra, Italy

$Co(n,\gamma)^{60}Co$

$Nb(n,\gamma)^{94}Nb$

$Nb(n,n')^{93\mu}Nb$

$Fe(n,x)^{54}Mn$

$Au(n,3n)^{195}Au$

$Ni(n,x)^{54}Mn$

$Ni(n,x)^{56}Co$

$Ni(n,x)^{57}Co$

$Ni(n,x)^{58}Co$

$Ni(n,x)^{60}Co$

$Ti(n,x)^{44}Ti$

$Ti(n,x)^{42}Ar$

$Ti(n,x)^{46}Sc$

Appendix II

Reactions Important for Activation

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Number	Reaction
1	^{11}B(n,d)
2	^{13}C(n,g)
3	^{13}C(n,a)
4	^{14}C(n,na)
5	^{14}N(n,p)
6	^{14}N(n,d)
7	^{14}N(n,np)
8	^{16}O(n,a)
9	^{17}O(n,a)
10	^{17}O(n,na)
11	^{20}Ne(n,a)
12	^{23}Na(n,a)
13	^{24}Mg(n,p)&
14	^{24}Mg(n,na)
15	^{26}Mg(n,g)
16	^{27}Al(n,2n)&
17	^{27}Al(n,a)&
18	^{27}Al(n,na)
19	^{28}Si(n,na)
20	^{28}Si(n,np)
21	^{28}Si(n,d)
22	^{30}Si(n,g)
23	^{31}Si(n,g)
24	^{31}P(n,g)
25	^{32}P(n,p)
26	^{34}S(n,g)
27	^{34}S(n,a)
28	^{35}Cl(n,a)
29	^{35}Cl(n,p)
30	^{37}Ar(n,np)
31	^{37}Ar(n,d)
32	^{40}Ar(n,g)
33	^{40}Ar(n,2n)
34	^{39}K(n,p)
35	^{39}K(n,a)
36	^{41}K(n,p)
37	^{40}Ca(n,a)
38	^{40}Ca(n,2p)
39	^{40}Ca(n,g)
40	^{40}Ca(n,np)
41	^{40}Ca(n,d)
42	^{42}Ca(n,2n)
43	^{42}Ca(n,a)
44	^{43}Ca(n,2n)

Number	Reaction	Number	Reaction
45	^{43}Ca(n,na)	102	^{62}Ni(n,g)
46	^{43}Ca(n,2p)	103	^{62}Ni(n,a)
47	^{44}Ca(n,2n)	104	^{63}Ni(n,a)
48	^{44}Ca(n,a)	105	^{64}Ni(n,2n)
49	^{44}Ca(n,na)	106	^{63}Cu(n,p)
50	^{44}Ca(n,g)	107	^{63}Cu(n,g)
51	^{45}Ca(n,a)	108	^{63}Cu(n,a)&
52	^{46}Ca(n,na)	109	^{64}Zn(n,2n)
53	^{46}Ca(n,g)	110	^{64}Zn(n,p)
54	^{48}Ca(n,2n)	111	^{64}Zn(n,na)
55	^{45}Sc(n,a)	112	^{64}Zn(n,2p)
56	^{45}Sc(n,p)	113	^{64}Zn(n,np)
57	^{45}Sc(n,g)&	114	^{64}Zn(n,d)
58	^{46}Sc(n,na)	115	^{64}Zn(n,g)
59	^{45}Ti(n,2n)	116	^{66}Zn(n,a)
60	^{46}Ti(n,a)	117	^{66}Zn(n,2n)
61	^{46}Ti(n,np)&	118	^{92}Zr(n,g)
62	^{46}Ti(n,d)&	119	^{93}Zr(n,a)
63	^{46}Ti(n,2n)	120	^{94}Zr(n,2n)
64	^{47}Ti(n,a)	121	^{94}Zr(n,na)
65	^{47}Ti(n,2n)	122	^{94}Zr(n,g)
66	^{48}Ti(n,a)	123	^{96}Zr(n,2n)
67	^{49}Ti(n,a)	124	^{92}Nb(n,2n)&
68	^{49}V(n,a)&	125	^{93}Nb(n,2n)&
69	^{51}V(n,a)	126	^{93}Nb(n,p)
70	^{51}V(n,na)	127	^{93}Nb(n,g)&
71	^{50}Cr(n,a)	128	^{95}Nb(n,2n)&
72	^{50}Cr(n,na)	129	^{92}Mo(n,2n)&
73	^{50}Cr(n,g)	130	^{92}Mo(n,g)&
74	^{50}Cr(n,np)	131	^{92}Mo(n,np)&
75	^{50}Cr(n,d)	132	^{92}Mo(n,d)&
76	^{52}Cr(n,a)	133	^{94}Mo(n,p)&
77	^{54}Cr(n,g)	134	^{94}Mo(n,2n)&
78	^{54}Mn(n,2n)	135	^{95}Mo(n,np)&
79	^{55}Mn(n,2n)	136	^{95}Mo(n,d)&
80	^{55}Mn(n,g)	137	^{98}Mo(n,g)
81	^{54}Fe(n,np)	138	^{100}Mo(n,2n)
82	^{54}Fe(n,d)	139	^{103}Rh(n,g)&
83	^{56}Fe(n,g)	140	^{103}Rh(n,na)&
84	^{56}Fe(n,2n)	141	^{104}Pd(n,g)
85	^{57}Fe(n,g)	142	^{105}Pd(n,g)
86	^{58}Fe(n,g)	143	^{106}Pd(n,g)&
87	^{59}Fe(n,g)	144	^{107}Pd(n,g)
88	^{58}Co(n,g)	145	^{108}Pd(n,g)&
89	^{59}Co(n,g)&	146	^{107}Ag(n,g)^{m}
90	^{60}Co(n,p)	147	^{107}Ag(n,p)&
91	^{60}Co(n,g)	148	^{107}Ag(n,2n)&
92	^{58}Ni(n,p)&	149	^{109}Ag(n,2n)^{m}
93	^{58}Ni(n,g)	150	^{109}Ag(n,g)^{m}
94	^{58}Ni(n,2n)	151	^{110}Cd(n,g)&
95	^{58}Ni(n,np)	152	^{111}Cd(n,g)
96	^{58}Ni(n,d)	153	^{112}Cd(n,g)^{m}
97	^{60}Ni(n,2n)	154	^{112}Sn(n,a)
98	^{60}Ni(n,p)	155	^{116}Sn(n,a)^{m}
99	^{60}Ni(n,np)	156	^{117}Sn(n,n')^{m}
100	^{60}Ni(n,d)	157	^{119}Sn(n,n')^{m}
101	^{61}Ni(n,g)	158	^{120}Sn(n,g)^{m}

Number	Reaction
159	^{122}Sn(n,g)^{m}
160	^{124}Sn(n,g)
161	^{125}Sn(n,g)
162	^{121}Sb(n,p)^{m}
163	^{121}Sb(n,g)
164	^{121}Sb(n,2n)
165	^{123}Sb(n,g)&
166	^{123}Sb(n,2n)&
167	^{124}Sb(n,g)
168	^{125}Sb(n,p)&
169	^{126}Sb(n,p)&
170	^{122}Te(n,g)^{m}
171	^{136}Cs(n,g)
172	^{137}Ba(n,p)
173	^{139}La(n,a)&
174	^{139}La(n,h)
175	^{140}Ce(n,2n)&
176	^{140}Ce(n,a)&
177	^{148}Nd(n,g)
178	^{150}Nd(n,g)
179	^{150}Nd(n,2n)
180	^{150}Sm(n,g)
181	^{151}Sm(n,g)
182	^{152}Sm(n,g)
183	^{152}Sm(n,2n)
184	^{151}Eu(n,g)
185	^{151}Eu(n,2n)^{m}
186	^{152}Eu(n,g)
187	^{153}Eu(n,g)&
188	^{153}Eu(n,2n)^{g}
189	^{154}Eu(n,g)
190	^{158}Gd(n,g)
191	^{160}Gd(n,2n)
192	^{159}Tb(n,2n)&
193	^{158}Dy(n,p)&
194	^{165}Ho(n,2n)&
195	^{165}Ho(n,g)^{m}
196	^{166}Ho(n,n')^{m}
197	^{164}Er(n,2n)
198	^{177}Hf(n,g)^{n}
199	^{178}Hf(n,n')^{n}
200	^{178}Hf(n,2n)&
201	^{178}Hf(n,g)^{n}
202	^{179}Hf(n,n')^{n}
203	^{179}Hf(N,2n)^{n}
204	^{180}Hf(n,2n)^{n}
205	^{180}Hf(n,g)
206	^{180}Hf(n,3n)^{n}
207	^{181}Hf(n,g)&
208	^{179}Ta(n,2n)&
209	^{181}Ta(n,na)^{g}
210	^{181}Ta(n,2n)^{m}
211	^{181}Ta(n,g)&
212	^{181}Ta(n,t)^{n}
213	^{181}Ta(n,nd)^{n}
214	^{182}Ta(n,p)&
215	^{182}Ta(n,g)
216	^{180}W(n,2n)&
217	^{182}W(n,a)^{n}
218	^{182}W(n,na)^{n}
219	^{182}W(n,g)&
220	^{183}W(n,g)
221	^{184}W(n,g)&
222	^{186}W(n,g)
223	^{186}W(n,na)&
224	^{185}Re(n,g)^{m}
225	^{187}Re(n,2n)^{m}
226	^{187}Re(n,g)&
227	^{188}Os(n,g)&
228	^{188}Os(n,p)&
229	^{189}Os(n,g)&
230	^{190}Os(n,g)&
231	^{190}Os(n,a)
232	^{192}Os(n,g)
233	^{192}Os(n,2n)&
234	^{191}Ir(n,g)^{n}
235	^{191}Ir(n,na)
236	^{191}Ir(n,2n)&
237	^{192}Ir(n,n')^{n}
238	^{193}Ir(n,2n)^{n}
239	^{192}Pt(n,g)&
240	^{194}Pt(n,2n)&
241	^{197}Au(n,a)&
242	^{197}Au(n,2n)&
243	^{195m}Hg(n,2n)
244	^{196}Hg(n,2n)^{m}
245	^{203}Tl(n,2n)
246	^{204}Pb(n,p)
247	^{204}Pb(n,t)
248	^{204}Pb(n,2n)&
249	^{204}Pb(n,n')^{m}
250	^{206}Pb(n,2n)
251	^{206}Pb(n,a)
252	^{208}Pb(n,g)
253	^{208}Bi(n,2n)
254	^{209}Bi(n,2n)
255	^{209}Bi(n,g)
256	^{210}Po(n,2n)

& indicates the sum of cross sections forming all isomeric states.

If particular isomeric products are required these are shown by:

g ground state ^{m} 1st isomer ^{n} 2nd isomer

CONCLUSIONS AND RECOMMENDATIONS

Workshop 2

Chairman: H.J. Nolthenius

Evaluation of Preliminary Results of the REAL-88 Interlaboratory Exercise

The last phase of the REAL-88 exercise was discussed, especially the topics related to the purpose of this Advisory Group Meeting:

A) IRDF-90 (to be released in the first half of 1990)

The participants of the workshop were informed on the present status of updating of the International Reactor Dosimetry File. The main changes are as follows: 15 new evaluations for threshold reactions have been included: 2 threshold reactions have been considerably modified (TI47P, NI60P); furthermore 4 new reactions have been added to the library. The uncertainty data are generally lower than in the previous edition. The capture cross sections remained unaltered. The IAEA Nuclear Data Section should ensure that

1. Irregularities of the capture reaction cross sections which were detected are corrected (mentioned in the report "The role of the REAL-88 exercise in the radiation damage characterization of nuclear facilities" of this Advisory Group Meeting).
2. The gas production cross sections of the IRDF-85 be updated.
3. Recent damage cross sections be incorporated.
4. The library be made available both in interpolable point data and 640 (SAND II) group format.
5. A report be issued (in the frame work of the REAL-88 exercise) on the differences between the IRDF-85 and IRDF-90.

B) Processing of cross section uncertainties

6. IAEA should organize comparison of multigroup cross section uncertainties calculated by the program package NJOY and UNC32/33.

7. The feasibility of supplying multigroup uncertainty data in a more suitable format for neutron spectrum adjustment should be investigated by the IAEA-NDS.

C) Contents of the REAL-88 reference file

The reference file will contain cross section libraries, input data sets for different adjustment tasks, a STAY'SL-type adjustment code, cross section processing codes and several utility programs, and a complete output set.

8. Both the IRDF-85 and IRDF-90 640-group cross section libraries should be present in the neutron spectrum adjustment reference file of the REAL-88 exercise. The IRDF-85 should be used for testing the user's adjustment procedure, while the IRDF-90 should be used for adjustment tasks in daily practice.

9. The situation with respect to the development of the STAY'SL-type code on PCs should be clarified before inserting it into the reference file.

10. As cross section processing codes, the UNC32/33 and FITOCO, both in standard FORTRAN-77 versions, should be included.

11. Among the utility programs should be present the STAYDEXP for calculating the (output) damage exposure parameters, and spectrum characterizing parameters. In special cases the code BLOWUP might be useful.

12. The ENDF pre-processing code package (RECENT, LINEAR, GROUPIE, etc.) need not be included in the reference file. It should be distributed separately.

D) Miscellaneous

13. The participants of the workshop suggested to the IAEA/NDS to organize in early 1991 a second Specialists' Meeting on the Requirements and Status of Covariance Data in Evaluated Data Files to review the progress since the Rome Meeting in 1986. They agreed that one of the most important tasks is to make

available the covariance information on the scattering cross sections.

14. It is reiterated that the users should perform a separate and detailed study of the effect of neutron self-shielding in activation detectors, and of the influence of covers around the detectors (e.g., Cd, Gd and/or the stainless steel wall of the reactor PV surveillance irradiation capsules). The impact of cover-material cross sections on the developed neutron spectrum should be investigated in detail.

15. The systematic differences which are detected between the STAY'SL and LSL adjustment procedures should be explained.

16. Neutron spectrum adjustment computations should be made more user-friendly.

E) <u>The "Post-REAL" situation</u>

After the distribution of the REAL-88 reference file, the "evaluators" will continue their work on the following items:

- testing the IRDF-90 in neutron spectrum adjustment calculations
- definition of new test cases for neutron spectrum adjustment runs using up-to-date information (probably also for fusion spectra)
- recommendations to the IAEA/NDS to organize the continuation of this workshop during the 7th ASTM-EURATOM Symposium on Reactor Dosimetry, and the following meeting at the time of the next AGM (probably in 1993), to discuss the state-of-art of neutron spectrum adjustment and radiation damage prediction.

IAEA Advisory Group Meeting on the STATUS AND REQUIREMENTS OF NUCLEAR DATA FOR RADIATION DAMAGE AND RELATED SAFETY ASPECTS

IAEA Headquarters, Vienna
19 - 22 September 1989

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