INDC 417

NCSAC-40
EANDC(US)-158 "A"
INDC(USA)-32 "G"

SURVEY OF MANPOWER AND FACILITIES TO MEET THE NEEDS OF THE U.S. APPLIED NUCLEAR ENERGY PROGRAM

May 21, 1971

Survey of Manpower and Facilities to Meet the Needs

of the U.S. Applied Nuclear Energy Program

The USAEC Nuclear Cross Sections Advisory Committee (NCSAC) has been asked to prepare a survey of manpower and facilities available to fill the needs for nuclear cross-section measurements. These needs are assayed from a working document of the Committee entitled "Compilation of Requests for Neutron Cross Section Measurements," which is periodically issued by the NCSAC. The latest version of this document (NCSAC-35) was issued in March 1971.

Final reports of NCSAC disciplinary subcommittees, reviewing the Request Compilation, were issued as NCSAC-36 in April 1971. In these subcommittee reviews, estimates were made of the manpower and facilities required to meet the needs, and specific recommendations were made for action to be taken in various special problem areas. Subcommittee estimates of manpower required to fill the average request varied from 1/3 - 1/2 man year per request for reaction, scattering, and total cross sections to 2.5 - 4 or more man years per request for fission, $\overline{\nu}$, and standards measurements. The total effort required to fill all the present requests in the compilation was conservatively estimated to be $\sim$ 800 man years. The Committee recognizes that this is a lower limit, applicable in a static technology; it is apparent that both the measurement techniques and the demands for nuclear data are changing rapidly.

In October 1970, a questionnaire was sent to a number of U.S. institutions, asking about the manpower and facilities available to meet the needs of the U.S. applied nuclear energy program. The responses received from this questionnaire are summarized in Tables 1-3. (A copy of the questionnaire is appended.) Table 1 lists the institutions to which questionnaires were sent and the total manpower in man years actively working this fiscal year in various applied areas. Of the 37 institutions surveyed, 24 replies were received. A partial list of experimental facilities, manpower, and percentage of running time given to the applied work is given in Table 2 for NCSAC contributors and others who answered the questionnaire. Comments received on requirements for separated sample material, possibilities of sample activation, and special fabrication needs are summarized in Table 3.

The intent of the survey was to point out special problem areas which currently may not be receiving the attention they deserve. The results of the survey indicated that about 118 man years of effort are currently being expended each year in measurements which are applicable to the needs of the U.S. nuclear energy program. The effort is fairly well correlated with the needs, as shown in Table 4, with the exception of problem areas in measurements requiring radioactive samples, and, to a lesser extent, in measurements of reaction cross sections.

The conclusions of the survey are based on comments received from those who responded: Present U.S. facilities appear to be adequate, but the available manpower is not. Budgetary restrictions are forcing many who have been productive in the field to seek funding in other areas, often unrelated to the needs reflected here. While still further curtailment of effort is the most likely prospect, it is hoped that the trend can be reversed.

Table 1. List of institutions to which questionnaires were sent, and breakdown of manpower into categories.

Laboratory	Total Manpower	Scattering	Capture	Fission	Total	Resonance Integral	Reactions	Thermal	Evaluations	Standards	Safeguards	Source Reactions	Spectra	Other or Unspecified	Comments
Atomics Int.	2.25	--	--	--	--	--	--	--	2.25	--	--	--	--	--	
Argonne Nat. Lab.	15.5	2	2	3	1	--	1	1	1	1	0.5	1	--	2	
Brookhaven Nat. Lab.	9.75	--	3.75	2	0.25	--	--	0.25	3.5	--	--	--	--	--	
Case Western Res. U.	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
Columbia U.	12	--	2	4	6	--	--	--	--	--	--	--	--	--	
Gulf Rad. Tech.	6	--	4	--	--	--	1.5	--	--	--	--	--	--	0.5	
Idaho Nucl. Corp.	(8)	--	--	(1)	(2)	2	--	--	(2)	--	(1)	--	--	--	Incomplete
LRL Livermore	16	--	3	4.5	--	--	0.5	0.5	2.5	--	1	--	4	--	
Lockheed Palo Alto	7	--	--	4	2	--	--	--	1	--	--	--	--	--	
Los Alamos Sci. Lab.	17	2.5	2	3	--	--	--	--	4	3	1	1.5	--	--	
Nat. Bureau Standards	3	--	--	1	0.5	--	--	--	--	1.5	--	--	--	--	
Nuclear Effects Lab.	7	4.2	1.4	--	0.14	--	0.56	--	--	--	--	--	--	0.7	
Oak Ridge Nat. Lab.	18.3	2.6	4.2	2.8	3.5	1.1	--	--	3.1	--	--	--	--	1.0	
Rensselaer Poly. Inst.	13.4	1	3	1	0.65	0.65	1.5	--	1.2	--	--	--	4.4	--	
Rice U.	(2)	--	--	--	--	--	--	--	--	--	--	(1)	--	(1)	No reply
Texas A & M U.	(1)	--	--	--	--	--	--	--	--	--	--	--	--	(1)	No reply
Texas Nuclear Corp.	2.6	1.3	1.3	--	--	--	--	--	--	--	--	--	--	--	
Triangle U. Nuclear Lab	17.2	0.5	--	2.7	1.7	--	0+	--	--	--	--	4.0	--	8.3	
Yale U.	0+	0+	--	--	--	--	--	--	--	--	--	--	--	--	
U. Kentucky	2.5	1.5	1	--	0+	--	--	--	--	--	--	--	--	--	
U. Illinois	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
U. Michigan	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
U. Washington	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
U. Oregon	7	2	--	--	--	--	3	--	--	--	--	2	--	--	
Iowa State U.	6	--	--	4	--	--	--	--	--	--	--	--	--	2	
U. Virginia	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
U. Colorado	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
U. Calif. (Berkeley)	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
U. Maryland	0+	--	--	--	--	--	--	--	--	--	--	--	--	--	
Princeton U.	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
Purdue U.	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
U. Minnesota	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
Kansas State U.	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
U. Kansas	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
U. Arizona	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
U. Calif. (Los Angeles)	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	Incomplete
Johns Hopkins U.	(0)	--	--	--	--	--	--	--	--	--	--	--	--	--	No reply
Washington State U.	0+	--	--	--	--	--	--	--	--	--	--	--	--	--	
Subtotal of answers received	11[illegible].5	17.6	27.65	31	13.74	3.75	8.06	1.75	20.55*	5.5	3.5	9.5*	8.4*	16.5*	

Note: The entry 0+ implies some interest or future plans but no significant active program at present.

*Not included in manpower subtotal.

Table 2. Experimental facilities for applied measurements

Laboratory	Facility	Total Manpower	Fraction of time for applied work	Special Features
ANL	4 MV Dynamitron	2	33%	1 mA protons DC, 2.5 ma bunched to 1 ns, on-line computer
"	CP-5 Reactor	4	100%	Internal target for γ-spectra, precision γ spectroscopy
"	20 MV Electron Linac	0.5	20%	8 A electrons in 5 ns pulses, ΔE = 3% at 10 MeV
"	8 MV Fast Neut. Gen.	7	100%	High intensity, pulsed and DC, large liq.scint.,time of flight
"	FN Tandem	2	10%	Heavy ion accel, mag. spectrograph, on-line computer
BNL	HFBR + Fast Chopper	3	50%	High beam intensity, 0.5% duty cycle, low background
"	HFBR + 2 Crystal Spec.	3.25	90%	Polarization capability, low background, high intensity
CWRU	4 MV Van de Graaff	0	0	Mobley buncher, 5 μA average current, polarimeter
GRT	40 MV Electron Linac	6	*	Large liq. scint.(2), total absorption GeLi detectors
INC	EBR-II Reactor	2	*	Mass spectrometer for fission yields
LRL (L)	100 MV Electron Linac	6	33%	Three target areas, short flight path, positron accel, rabbit
"	3 MW Reactor	6	33%	*
"	14 MV ICT	1.5	33%	Highest intensity 14 MeV neutrons in U.S.
"	30 MV Cyclograaff	*	33%	High intensity, high resolution, high energy
Lockheed	3.5 MV Van de Graaff	7	10%	Triton accel, nuclear orientation capability
LASL	5 MV Van de Graaff)	6	25%	Mobley buncher
"	15 MV Van de Graaff)		25%	Klystron buncher
"	Nuclear explosion	8	100%	High intensity single burst
NBS	3 MV Van de Graaff)	2	75%	)
"	150 MV Electron Linac)		10%	) Availability of 3 machines in 1 group
"	Reactor	1	100%	)
NEL	FN Tandem)	7	40%	1 ns pulse, 3^{o}-15^{o} forward scattering collim.,large target room
"	750 kV C-W)		50%	3 ns pulse
RPI	100 MV Electron Linac	9	100%	3 ns pulse, 15-20 A current planned, 4 flight tubes
Yale U.	Electron Linac	0+	20%	ns time-of-flight system, advanced technique devel.
U. Kentucky	Van de Graaff	2.5	*	1 ns pulse, dynamically biased neutron detector
U. Oregon	4 MV Van de Graaff	7	*	Intense ns pulsed beam, 4 beam pipes
Iowa State U.	70 MV Synchrotron)	6	50%	ΔE = 20 keV at 70 MeV, Compton scattering spectrometer
" " "	5 MW Reactor)		100%	Isotope separator for fission products
U. Maryland	Cyclotron	0+	0	Up to 100 MeV neutrons at 10^{6}/sec
U. Arizona	*	0	0	*
U. Kansas	*	0	0	*
Columbia U.	550 MeV proton synchrocycl.	12	12%	Highest average intensity presently obtainable for high resolution neutron spectroscopy.
Texas Nuclear	3.2 MV Van de Graaff	2.5	100%	Large anti-Compton total absorption gamma spectrometer.
TUNL	5 MV Van de Graaff)			
TUNL	4 MV Van de Graaff)	17.2	> 50%	High resolution H, He beams from 1-15 MeV,
TUNL	15 MV Tandem)			high resolution neutron beams at high energy.
TUNL	30 MV Cyclograaff)			
U. Washington	25 MV 3-stage Van de Graaff	*	0	H beam to 24.6 MeV, He beam to 27 MeV, 1 no bunching to 18 MeV.
U. Washington	60 inch cyclotron	*	0	100 μA 22 MeV deuterons or 42 MeV alphas, pulse width 0.7 ns.
Wash. St. U.	2 MV Van de Graaff)	0+	*	Radiochemical facilities also available.
Wash. St. U.	1 MW Triga III Reactor)			
ORNL	140 MV electron linac)		100%	High resolution (5 ns at 15 A), advanced design data acquisition.
ORNL	5.5 MV Van de Graaff)		85%	High performance pulsed beam (2 ma, 1 ns), on line data acquisition.
ORNL	3.3 MV Van de Graaff)	18.3	50%	High performance pulsed beam, special facility for d,d neutrons, on-line data acquisition.

*Unspecified

Table 3. Separated sample and fabrication requirements.

Laboratory	Facility	Separated sample requirements	Will activation Occur?	Special fabrication requirements
ANL	4 MV Dynamitron	Only occasional demand	No	Standard form OK for scattering. Need also thin foils.
"	CP-5 Reactor	1 g amounts of broad range of isotopes	Yes	) Powdered samples are convenient.
		~6 samples of 0-10 g amount, irradiated	Yes	) Standard samples could be used.
"	Electron Linac	~8 samples of 10-50 g each year. Broad range.	No	Standard samples OK, form not critical
"	Fast Neut. Gen.	Need high purity, low fabric. cost.	No	Standard form too small. Need metal samples, fission foils.
"	Tandem	Small amounts on thin foils	No	Done in-house
BNL	Chopper	High purity & enrichment, 100 g quantities of $^{233,234,236}U$, $^{240,242}Pu$, ^{91}Zr, ^{147}Sm, $^{185,187}Re$, ^{195}Pt, ^{105}Pd, ^{187}Os, ^{143}Nd, $^{199,201}Hg$, $^{191,193}In$, ^{111}Cd, ^{135}Ba.	No	Standard samples not useful. Powdered oxides are most convenient.
	Crystal Specs.	$^{143,145}Nd$, $^{147,149}Sm$, $^{155,157}Gd$, ^{235}U (low ^{234}U), 5-10 g of Os, clean ^{237}Np, ^{242}Pu, some ^{124}Xe	No	Standard sizes OK, need precise analyses & uniformity. Rectangles 1"x 1.5", thicknesses 0.1, 0.3, 1.0 g/cm^2
INC	Reactor	> 99% enriched stable fission products	Yes	Probably none.
LRL	Linac	Larger & greater purity Cm samples and heavier isotopes.	No	Fission foil fabrication.
Lockheed	Van de Graaff	Gram quantities of ^{30}Si, ^{26}Mg, ^{48}Ca, & rare earths.	No	Metallic samples in cylindrical shape. Rare earths in single crystals or poly crystals.
LASL	Nucl.Explosion	Need 10-20 mg separated radioactive targets	Yes	Thin deposits on stainless steel backings.
NBS	Linac	Thin foils ^{6}Li, ^{10}B, ^{235}U, ^{238}U, ^{239}Pu, ^{237}Np. Need 100-500 g ^{238}U.	No	Fission foils.
NEL	Tandem	Very small quantities, need D/T for neutron sources.	No	None
RPI	Linac	1 mole quantities of reactor structural, shielding, and fissionable isotopes	No	Need metals, 1/2x1/2x1/32" modules would be useful.
U. Kentucky	Van de Graaff	0.1-0.5 moles of highly enriched (> 90%) in elemental form. Metal cylinders of isotopes of Ce, Ba, Te, Ru, Pd, Sn.	No	High enrichment, uniform density, high purity (≤ 1% Oxygen) metal cylinders, not less than 0.1 mole. Standard size mentioned is useable but circular disks are preferable.
U. Oregon	Van de Graaff	~100 mg metallic samples of all metal isotopes below Sn, having (p,n) thresholds < 4 MeV.	No	Foils for use in charged-particle beams in vacuo.
Iowa State U.	Synchrotron	Thin foils ~1 x 3" of fissile isotopes	No	Fissile foils in shape of cylinder 1"D x 3".
U. Maryland	Cyclotron	0.1 g or less thin foils as targets	Yes	Fabrication by AEC lab preferred.
U. Arizona		0.1 g needed of various materials	No	None.
ORNL	ORELA	0.05 g-atom of separated isotopes; kg of high purity ^{235}U	No	Standard samples OK in most cases.
TUNL	Cyclograaff	Rare isotopes with A < 60, magic nuclei, Pb, Tl, Ba, Sr	No	Standard samples should be adequate.
U. Washington	Van de Graaff	mg quantities of magic nuclei, Ca, K, Ti; Rb, Sn, Y, Zn, Mo; Cd, In, Sn, Sb, Te; Tl, Pb.	Yes	Thin foils, 10-500 μg/cm^2 with 1 cm^2 area, fabricated in-house.

Table 4. Distribution of requests for measurements and effort currently being expended.

<table>
<tr><th>Category</th><th>Fraction of Requests in this Category</th><th>Fraction of Effort Expended in this Category</th></tr>
<tr><td>Elastic, inelastic scattering, gamma radiation from inelastic scattering</td><td>0.125</td><td>0.156</td></tr>
<tr><td>Gamma-ray production and radiative capture, stable targets</td><td>0.239</td><td rowspan="2">0.246</td></tr>
<tr><td>Resonance parameters, non-fissile</td><td>0.029</td></tr>
<tr><td>Fission, $\bar{\nu}$, alpha, eta, and nuclear data for safeguards</td><td rowspan="2">0.260</td><td rowspan="2">0.306</td></tr>
<tr><td>Resonance parameters, fissile</td></tr>
<tr><td>Resonance integrals</td><td>0.026</td><td>0.033</td></tr>
<tr><td>Thermal and moderator cross sections, measurements with radioactive samples</td><td>0.111</td><td>0.015</td></tr>
<tr><td>Total cross sections (incl. standards)</td><td>0.047</td><td>0.122</td></tr>
<tr><td>Fast neutron reactions and thresholds</td><td>0.124</td><td>0.072</td></tr>
<tr><td>Standards</td><td>0.040</td><td>0.049</td></tr>
</table>

1. How many man-years per year of scientific staff (excluding support staff) are currently involved in measurements or evaluations related to the U. S. applied nuclear energy program, as reflected in the Compilation of Requests for Nuclear Cross Section Measurements (WASH-1144)?

2. Of these scientific man-years of effort, what part will be involved this fiscal year in the following categories?

   A. Elastic and inelastic scattering of fast neutrons

   B. Neutron capture or gamma-ray production

   C. Fission or other measurements on fissile nuclides

   D. Total neutron cross sections

   E. Resonance integrals

   F. Fast neutron reaction cross sections and thresholds

   G. Thermal neutron cross sections

   H. Evaluations (please specify)

   I. Other (please specify)

3. What facilities will be used to make the measurements or evaluations, and what fraction of running time will be used for applied work of this type?

4. What are the unique features of your facility?

5. What specific requirements for isotopically separated samples do you foresee over the next several years?

6. Will any of these samples be activated to a significant extent by the measurement?

7. Will you require special sample fabrication (metallic samples, special shapes, etc.) for separated material? Could you use standardized samples, such as 1/2" x 1/2" x 1/32" squares which could be stocked according to your needs. Please specify what you would need.