Finally, it should be noted that the data employed for Hf^{177} and Hf^{178}, which yield good agreement with the intermediate-spectrum experiment, also represent the major contribution (~95%) to the conventional natural-hafnium resonance integral of about 2000 barns. Thus the results of the present study are consistent with the work of F. Feiner[5] and I. Itkin[1] where it is concluded that a resonance integral closer to 2000 rather than 2800 barns is appropriate for natural hafnium.

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*Operated by the General Electric Company for the U. S. Atomic Energy Commission.

[5] KAPL-2000-16, Reactor Technology Report No. 19 - Physics, December 1961, "Resonance Integrals of Manganese, Hafnium and Niobium," by F. FEINER.

In^{115} Thermal Cross Section Ratios*

In a recent paper by K. H. Beckurts *et al.*[1], data are given for the ratio of thermal activation cross sections for the 14-sec and 54-min activities of In^{116} produced by capture of thermal neutrons in In^{115} which is in "striking disagreement" with that obtained by the Greenfield-Koontz's[2] re-evaluation of Domanic and Sailor's[3] experiment.

Domanic and Sailor had published data on the dependence of the In^{116} activation ratio on neutron energy. They found that foils of different thicknesses (26.8 and 96 mg/cm^2) gave quite different values for the activation ratios for pile neutrons; their values are listed as $A_{14\ \mathrm{sec}}/A_{54\ \mathrm{min}}$ in column 2 of Table I. In a subsequent pubication[2] we suggested the need to take account of the rather different values for self-absorption and self-scattering for these foil thicknesses for the beta spectra corresponding to the 54-min activity. In Reference 2 application of the correction factor for an end-window G.M. detector with narrow geometry (7%) did remove the anomaly observed by Domanic and Sailor[3]. The correction factors were used for the 54-min activity only.

The choice of the narrow geometry correction factors has now been reviewed, and it has become apparent that the self-absorption and self-scattering factors appropriate for 2π or 4π geometry should have been used. This becomes clear when one examines the geometry employed by Domanic and Sailor[3]. Values for the correction factors, $f_{s,54\ \mathrm{min}}$, for 2π geometry[4,5] are given in column 3 of Table I for the foil thicknesses of interest. It also appears from the work of Beckurts *et al.*[1], that a correction factor for the short-lived activity, $f_{s,14\ \mathrm{sec}}$, should be used. Table I summarizes the original data of Domanic and Sailor as well as the various correction factors just described, and also presents corrected ratios of the activities; i.e. the ratio of thermal activation cross sections.

Table I indicates that the anomalous results for differing foil thicknesses are removed by including the self-absorption and self-scattering correction factors. Further, the application of the correction factors of Table I to other data reported by Domanic and Sailor[3] indicates no dependence of the ratio of the 14-sec to 54-min activities on the neutron energy up to 2.66 eV (as had been pre-

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*This work was done under the auspices of the USAEC.

[1] K. H. BECKURTS, M. BROSE, M. KNOCHE, G. KRÜGER, W. PÖNTIZ and H. SCHMIDT, *Nucl. Sci. Eng.* **17**, No. 3, 329 (1963).

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[3] F. DOMANIC and V. L. SAILOR. *Phys. Rev.* **119**, 208 (1960).

[4] M. A. GREENFIELD, R. L. KOONTZ, A. A. JARRETT, *et al.*, *Nucleonics* **15**, No. 3, 57 (1957).

[5] M. A. GREENFIELD, R. L. KOONTZ and A. A. JARRETT, "Absolute Beta Counting of Indium Foils," Part II, NAA-SR-1137, Atomics International, (1955) (unpublished).

TABLE I

Ratio of 14-sec to 54-min Activities of In^{116} Corrected for Self-Absorption and Self-Scattering based on 2π or 4π Geometry.

Foil thickness mg/cm^2	Ratio of activities[3] $A_{14\,\mathrm{sec}}/A_{54\,\mathrm{min}}$	$f_{s,54\mathrm{min}}$[4,5] (for 2π or 4π geometry)	$f_{s,14\mathrm{sec}}$[1]	Corrected ratio of activities $\frac{A_{14\,\mathrm{sec}}/f_{s,\,14\,\mathrm{sec}}}{A_{54\,\mathrm{min}}/f_{s,\,54\,\mathrm{min}}}$
96	0.586	0.339	0.86	0.231
26.8	0.331	0.632	0.94	0.223

viously reported[2]). Strictly one should use scattering correction factors based on the precise geometry employed by Domanic and Sailor. This may partly explain the 13% difference between the mean value of 0.23 in Table I and the 0.26 value of Beckurts *et al.*[1]. This suggests that the value reported by Beckurts is more correct.

Some years ago(in 1956 while preparing References 4 and 5) we had performed preliminary measurements on the ratio of the 14-sec to 54-min activities of In^{116} by exposing a 3.5 mg/cm^2 foil in an Atomics International Solution Reactor operating at approximately 2 watts. The ratio obtained of the 14-sec and 54-min activities was 0.26.

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Cross Section and Half Life for the Fe^{54} (n,p) Mn^{54} Reaction

Clare, Martin and Kelly[1] have determined the average 'fission' cross section of the $Fe^{54}(n,p)$ Mn^{54} reaction to be 73 mb relative to 107 mb for the Ni^{58} (n,p) Co^{58} reaction. This determination involved the use of a half life of 291 d[2] for Mn^{54}. There is at present, however, some discrepancy in reported values of this half life[2,3,4], ranging between 291 and 314 d. In their experiment performed in the Harwell materials testing reactor PLUTO, Clare et al[1], irradiated enriched iron (95% Fe^{54}) foils enclosed in gadolinium to reduce thermal-neutron activation of the small fraction of Fe^{58} in the foils. This competing activation was subsequently shown to be negligible for these foils. The decay of the activities of three of these foils has been followed for one half life of Mn^{54}, and this half life has been determined. The method of measurement using a T.P.A. ionization chamber has been described by Clare *et al*[1]. The first activity measurement, S_1, in the decay was made at a time t_1, 102 d. after the end of the irradiation, and the results are plotted in Figure 1 as the logarithm of the ratio of S_1 to the activity at time t_2 as a function of the time interval between measurements, $(t_2 - t_1)$. The best straight line through the results has been calculated by the least-squares method and the half life of Mn^{54} given by this line is (303 ± 1) d.

The long-term drift of the ionization chamber readings appears from the Co^{60} standard measurements to be random within ± 3%, and short-term variations show that the ratio of measured Mn^{54} to Co^{60} activities varies much less than this. Therefore, the ionization-chamber factor of 2.84 reported by Clare *et al.*[1], which allows for the different decay schemes of Mn^{54} and Co^{60}, is expected to be essentially constant throughout the time of the investigation, about 300 d.

Substituting the value of 303 d for the Mn^{54} half life, determined in this investigation, into the results of Clare *et al.*, the mean 'fission' cross section for the Fe^{54} (n,p) reaction is (76 ± 3)mb. This now gives the ratio of $\sigma(Ni^{58})/\sigma(Fe^{54})$ as 1.41, in better agreement with the value of 1.38 determined by Hogg and Weber[3] than the previous value of 1.46 reported by Clare *et al.*, using 73 mb for the Fe^{54} (n,p) reaction.

An enriched iron foil has been irradiated together with nickel and cobalt monitors for 3 months in a hollow fuel element in the Harwell materials testing reactor DIDO. The cross section obtained from this irradiation, using 303 d for the Mn^{54} half life, is 74 mb relative to 107 mb for the $Ni^{58}(n,p)$ reaction. This is in good agreement with the value of (76 ± 3) mb. more accurately determined from the 3-day irradiation in PLUTO.

Clare *et al.*[1], give the correction for thermal-neutron activation of Fe^{58} present in iron foils by the following equation.

$$\frac{S_{\text{app}}}{S_{\text{true}}} = 1 + C\cdot\frac{\phi_{th}}{\phi_f}\,\frac{[1-\exp.(-\lambda_{58}t_i)]}{[1-\exp.(-\lambda_{54}t_i)]}\,\frac{\exp.(-\lambda_{58}t_0)}{\exp.(-\lambda_{54}t_0)}\ ,$$

$$\text{where } C = \frac{a_{58}\,\sigma_{58}}{a_{54}\,\sigma_{54}}\cdot\frac{A_{54}f_{54}}{A_{58}f_{58}}\ ,$$

σ_{58} = thermal neutron activation cross section of Fe^{58}

σ_{54} = fast neutron activation cross section of Fe^{54}

a_{58} = abundance of Fe^{58} in the foil

a_{54} = abundance of Fe^{54} in the foil

A_{58} = atomic weight of Fe^{58}

A_{54} = atomic weight of Fe^{54}

λ_{58} = decay constant of Fe^{59}

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