DISCUSSION

E. Landerman[1]—In the list of dosimeters, ^{237}Np and ^{238}U were not suggested for use in surveillance programs. Westinghouse has been using them successfully; K. M. Barry and J. A. Corbett have described their use in a recent ANS paper, "Measurement of Neutron Fluence by ^{237}Np and ^{238}U Fission Dosimeters." [2] Their results show that from test performance in dissimilar reactors such as the Saxton reactor and the Babcock and Wilcox test reactor (BAWTR), the combination of fission dosimeters, with the P_1MG Code to predict the neutron energy spectrum, yields fast neutron fluences in good agreement with values obtained from the ^{54}Fe monitors.

The data below are from the Saxton reactor:

Reaction	Fast Neutron Fluence, n/cm^2, E >1 MeV
$^{237}Np(n,f)^{137}Cs$	1.18×10^{20}
$^{238}U(n,f)^{137}Cs$	1.17×10^{20}
$^{54}Fe(n,p)^{54}Mn$	1.15×10^{20}

Noting these good relationships, why were they not included and considered in this paper?

A. D. Rossin[3]—I wish to take exception to the statement in the third paragraph of this paper: "With present technology, the best alternative is to make mechanical property measurements on specimens irradiated at nearby accessible locations in the same reactor and extrapolate the mechanical property changes to the location of interest."

This statement is certainly not correct and is misleading to the reader. Any technique that extrapolates to another position in a reactor system could work equally well with any position in any materials testing reactor. The advantages of ease of handling, temperature control, better dosimetry, and factors of 10 to 1000 less irradiation time required because of higher flux levels available far outweigh the problems that go with surveillance.

[1] Fellow engineer, Westinghouse Nuclear Energy Systems, Pittsburgh, Pa. 15230.

[2] June 1970 Annual Meeting, *Transactions of the American Nuclear Society*, TANSA, Vol. 13, No. 1, pp. 431–432.

[3] Center for Environmental Studies, Argonne National Laboratory, Argonne, Ill. 60439.

Moreover, in order to design reactors there must be experimental evidence on the behavior of irradiated pressure vessel steel throughout the reactor lifetime. To date, designs have met requirements for safety analysis by substantial overdesign. The surveillance approach was accepted by review bodies several years ago as a backup to the limited experimental evidence. Unfortunately, there was no real basis for believing that surveillance would prove worthwhile. This paper notwithstanding, there is still no valid reason to believe that surveillance is either necessary or desirable. Surveillance offers evidence of good intentions on the part of the vendor and has the distinct short-term advantage of giving nothing to evaluate for many years. Hopefully, the design will turn out to have been conservative enough regardless of the findings.

What is still missing is adequate experimental evidence to support design calculations. Because the industry has accepted overdesign, neither it nor government has seen fit to support sufficient research to put this problem to bed.

Two additional points:

1. I might defend the RDU or Dt approach to this extent: the concepts work with any set of displacement cross sections, and results can easily be updated if a new and better set of cross sections is developed. As for a "damage unit scale in addition to the fluence scale," since the fluence scale fails to give the correlation required, who needs it?

The problem with use of an effective energy cutoff [*16*] is that to validate it for specific cases one must go through the whole damage model approach first, and then the effective energy cutoff limits the usefulness to the cases tested. Unfortunately, to those not familiar with radiation damage, the energy cutoff model gives the impression that only the neutrons with energy above that value cause the damage. This impression has led to much confusion in the past.

2. In practice, determination of neutron spectra turns out to be an experiment that takes substantial effort to perform and skill to interpret. It can be done in special locations, in test reactors, or in mockups, as described in the paper. For power reactors, for long-term irradiations, knowledge of flux and spectra at points of interest, whatever methods are used to determine it, can best be used along with operating history to determine fluence and damage.

What is needed by the power reactor industry at this stage is to get rid of surveillance. Specimens in reactors have broken loose creating potential safety problems. They add to cost, complicate flow patterns, and do not add to safety. Even with accelerated locations, they beg the question. If surveillance specimens predict vessel damage, a $100 million operating plant is in a lot of trouble. The knowledge is needed early, not later on.

C. Z. Serpan, Jr. (*authors' closure*)—The discussion by Mr. Landerman is in reference to presentation of this paper which was a condensation of papers by Serpan and by Odette and Ziebold. In the presentation, ^{237}Np and ^{238}U were omitted from the list of neutron flux detectors on the basis of a rather difficult analysis procedure required, in particular for ^{237}Np. It should be noted, however, that in this final version of the paper these two fission detectors are included.

The discussion by Dr. Rossin permits the continued airing of important divergent views on dosimetry, spectrum, and surveillance. The first comment refers to extrapolation of surveillance results and is not withdrawn by the authors. The statement has been refined in the text, however, to clarify the intent: surveillance irradiations should be made as close as practicable to the location of interest, as this effectively minimizes spectrum, temperature, and flux differences, hence, a significant reduction in potential errors. As this was the original intent of the statement, it was reemphasized in the paragraph preceding the summary and conclusions section. Damage models, trends, approximations, error bands are not needed to evaluate data that have been obtained from irradiation at, or virtually at, the location of interest. As Dr. Rossin says, "there must be experimental evidence on the behavior of irradiated pressure vessel steel through the reactor lifetime." Where better to obtain such *realistic*, not accelerated nor test reactor, data? If surveillance is no good, what alternative does the responsible reactor operator have *today* to assess the future potentially frangible condition of his reactor vessel? Research has been and is continuing to be conducted on this very topic. If the past ten or twelve years of research have provided as little useful information as suggested by Dr. Rossin, then what will come from ten or twelve more years of research?

The question of an energy "cutoff" such as ">1 MeV" is one that has been with us since the onset of radiation effects testing. Dr. Rossin was one of the first to point out the shortcomings of the concept and, in general, these are recognized and accepted. Nevertheless, no agreement has yet been reached regarding what to use in place of a threshold. The fact is that research data must be placed into terms that can be understood and used by design and operating personnel. Elegant and complicated analysis techniques simply will not be used on a daily working level basis. Thus, it is the obligation of those working in this field not only to mold their techniques for simple use but also to provide reference marks along the way in old, familiar terms to help guide the uninitiated.

It is felt that great progress has been made toward understanding the radiation embrittlement problem and toward solving it. I need only point to the paper by Hawthorne in this volume showing the dramatically reduced embrittlement potential demonstrated on a 30-ton heat of A533B pressure vessel steel produced by composition control. This shows what kind of experimental evidence can and is being developed to support the future design of reactors.