LETTERS TO THE EDITOR

COMMENTS ON REVIEW OF *THE ACCIDENT HAZARDS OF NUCLEAR POWER PLANTS*

In the Mid-April issue of *Nuclear Technology*,[1] Professor Hugh Henry reviewed my treatise *The Accident Hazards of Nuclear Power Plants* (University of Massachusetts Press, 1976), which is a report of my six-year, full-time study of nuclear reactor accident hazards and safety. I must reply to Henry's review because he grossly misrepresents the book.

First, he thinks the book leaves the impression that design basis accidents (DBAs) can be anticipated as "near-routine occurrences." However, the book makes no contention that DBAs are likely to occur, expressed or implied, nor does Henry show specifically how he gets his impression. In fact, the book states that "extensive measures are taken to minimize the likelihood of serious reactor malfunction," and describes the DBAs as "the most serious reactor accidents considered in federal government licensing," which does not indicate that their occurrence will be near routine. Moreover, I noted that a DBA has never occurred. However, I asserted that negligible accident probability figures cannot be proven, and thus we do not really know what to anticipate for the future, when reactors multiply and age. The book concludes that we can only assess safety by considering all accident possibilities and then make a judgment. That is the task before us.

Henry ignores the stated purpose of the book. The book does not purport to be a full safety evaluation that would discuss the detail measures and reactor component qualities that tend to reduce the likelihood of the DBAs. [I note only the basic protection, such as two scram systems for liquid-metal fast breeder reactors (LMFBRs).] Rather, the book is a synopsis of the findings of my study, including the facts that there is a vast set of worst accident possibilities that have not been analyzed but need to be and that the DBA analyses have serious experimental deficiencies. The book suggests specifically how the issues should be investigated and resolved. Since the nuclear community argues that a reactor will be safely controlled in the event of a DBA, the logical starting point in evaluating safety is to inquire whether the DBA analyses are theoretically and experimentally sound and then to inquire whether there are worst possible accidents (WPAs). This is what the book does. If Henry gets the impression that we can anticipate DBAs occurring somewhat frequently in the future from the factual information in the book about near-accident malfunction and the causes of DBA-level accidents not discussed in official safety analyses, then that might be a justified impression.

As to the WPAs, Henry asserts that I assume only the worst possible consequences, but in fact I noted that there is a range of consequences, from minor levels to those that could be extremely serious. The fact is that there has been no analysis of the potential consequences of the worst reactor accident possibilities except for what my book sketches. Should not there be?

Henry asserts that in using the 1957 WASH-740 report for extrapolating the potential consequences of of accidents in today's large plants, I "brushed off or ignored" subsequent commentary on WASH-740, and he further asserts that the book does not review the Rasmussen Report and the American Physical Society report, despite his acknowledgment that a chapter is devoted to each report. (He neglected to note my appendix on the final Rasmussen Report.) On the contrary, the book rather thoroughly reviews those reports, including quite detailed analyses of such things as the neglect of nuclear runaway accidents, assumptions of fission product release fractions, the derivation of ^{90}Sr ground contamination limits, probability analysis, and so on. Based on a careful, substantiated, and documented analysis, the book concludes that the WASH-740 report has not been demonstrably superseded, and that it must therefore be used as a basis for assessing potential accident consequences, at least until such time as the outstanding questions are resolved. The book frames a specific scientific approach for resolving the questions.

Henry asserts that the book does not "attempt . . . to estimate [accident] occurrence probabilities," which is also untrue. I estimate the probabilities, with allowance for uncertainty, of transients without scram in boiling water reactors, the control rod ejection accident, and steam explosion upon molten fuel and coolant interaction, and devoted sections on the subjectivities inherent in any probability figure.

Henry asserts that the book "makes no attempt to evaluate the validity of the safety factors and other special safety provisions." This too is untrue. The book contains an extensive evaluation of safety factors, involving such topics as space-time neutron kinetics, fuel rod failure thresholds, fission power during a loss-of-coolant accident, local core power-cooling mismatch, molten uranium oxide-sodium interaction, conservatism in DBA calculations, scram reliability, fuel bowing reactivity coefficients (LMFBR), and so on.

He alleges that the book concludes that the experiments needed to establish the accident hazards are too expensive and hazardous to undertake, and he then asserts that "no attempt is made . . . to give a balanced presentation . . . ." These claims are also untrue. The book expresses very strong doubts that an adequate experimental program is practical (not a firm conclusion). However, in an effort to provide balance, the book enumerates the experimental needs and difficulties and sketches a minimum research program for the light water reactor and the LMFBR that might be practical, including accident bounding tests—all of which

is presented to promote a thorough review by the scientific community, so that the extremely complex question of where we should require and draw the line on experimental verification can be resolved wisely. Also, the subject of accident prevention measures in the LMFBR is addressed quite fairly, I believe—another example of balance.

Regarding my detailed analyses of 14 serious mishaps in reactors, Henry implies that the analyses are simplistic and biased toward a conclusion that mere luck prevented the WPA. On the contrary, the analyses are quite rigorous and explain the mitigating circumstances, such as the fact that the Fermi core contained little radioactivity when it suffered the partial fuel meltdown accident.

Most important, Henry does not examine and dispute any specific details in the book to justify his opinion that the book fails to be "sufficiently valid . . . to be an important contributor" to safety assessment. Instead, he makes a trivial complaint about the book's figure of 100 mrad/yr for natural radiation. He thinks that is on the low side. (I said "about 100," and referenced David Inglis's *Nuclear Energy: Its Physics and Its Social Challenge*, which states 126 mrad.) Henry also notes my suggestion that we might use the U.S. Environmental Protection Agency (EPA) proposed 25 mrad/yr limit (for normal fuel-cycle exposure), instead of the Rasmussen Report's assumed 500 mrad/yr maximum acceptable dose, in establishing contamination limits for assessing accident consequences. Henry asserts that these two examples show that I am determined to put the worst possible light on reactor safety. On the contrary, the book merely addresses the facts. I am not a biologist who is able to say what radiation dose is safe and unsafe and, therefore, I must note expert opinion on safe radiation limits, especially since no biologists or health authorities have attested to the assumed exposure limits in the Rasmussen Report's accident-consequence section and since the authors of the report disclaim responsibility for the accuracy and completeness of the information in the report, which the book points out. Subsequent to the book, the EPA has concluded in an impressive analysis (EPA-520/3-76-009) that the Rasmussen Report undercalculates the cancer risk of a given dose of radiation by a factor of 5 and possibly as much as 10, and that the report cannot be checked for other calculations, conclusions that support my book. Henry should prove that the EPA is in error if he believes that 500 mrad/yr is acceptable, as he vaguely implies.

Since Henry's expertise is in the field of radiation protection, I would think he would have evaluated (a) the detailed calculation given in the book (Appendix 1) of the agricultural ground contamination limits for ^{90}Sr fallout, which supports the conclusion that a reactor accident could conceivably cause agricultural restrictions over an area of as much as one-half of the land east of the Mississippi; (b) the book's ground contamination limits for plutonium from an LMFBR nuclear explosion accident, which indicate a potential for abandonment of 150 000 square miles of land due to plutonium fallout—an area equal to Illinois, Indiana, Ohio, and half of Pennsylvania, combined; and (c) the other comments in the book on radiological consequences and questions. Instead, he avoids commenting on these substantive matters. I must, therefore, assume the analyses are correct. What is needed is detailed examination of the validity of safety and hazards analyses, not rhetorical reviews.

The most important conclusion of the book escaped Henry's attention, and that is that the government and nuclear community have not analyzed the most serious classes of reactor accident possibilities for either their potential consequences or their likelihood (nuclear runaway being the most serious class), and that, therefore, a full accurate hazards analysis (with no disclaimers of accuracy and completeness) should be prepared to enable the people and their constitutional representatives to make an informed judgment on the safety issue. Is this not wise? Or will Henry and the other members of the nuclear community join with me in calling for this analysis and for it to be prepared by a truly independent team of qualified and independent-thinking scientists and engineers, drawn heavily from the national laboratories. It is especially discouraging to this nuclear engineer, who only wants to ensure that society knows the full extent of the hazards and uncertainties to ensure our safety and well-being, that the U.S. Nuclear Regulatory Commission (NRC) has denied a petition to investigate the risk of "class nine" accidents (accidents worse than the DBAs) in a licensing hearing in Oklahoma (Black Fox), where I, along with many concerned citizens of that area, have sought to have the subject systematically and authoritatively investigated. To further shield the NRC's Rasmussen Report from decisive examination, the NRC announced in that proceeding that it would not rely on the Rasmussen Report in its testimony (a scheme to avoid having to subject the report to cross examination, subpoenaing of scientists, and countering testimony). But if the NRC will not rely on the Rasmussen Report, its official reactor safety study, and subject it to deliberate examination, then what study do they have to conclude that reactors are safe?

Henry's review is replete with misrepresentations that I could continue to cite. Instead, I will stop here and simply invite all nuclear engineers and scientists to read my treatise for themselves. I do not claim it to be the last word, but only a basic contribution. We scientists and engineers ought to use our skills toward promoting the safety and happiness of the people, whether it be in making safe nuclear plants or in creating the technology for an alternate way of life, should the informed judgment of the people be that nuclear power is unsafe. Accordingly, let us inform the people by preparing a full hazards and safety analysis and then trust their judgment. The people will appreciate it and protect our economic well-being if we do.

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REFERENCE

1. HUGH F. HENRY, "Review of *The Accident Hazards of Nuclear Power Plants*," *Nucl. Technol.*, **33**, 237 (1977).