ES&T VIEWS

Health effects from radiation

By Robert E. Alexander

In the article "Nuclear Safety after Chernobyl," Christopher Flavin correctly observes that the Three Mile Island and Chernobyl nuclear accidents cast spotlights on unresolved safety problems (*ES&T,* Views, July 1987, pp. 624–25). However, the spotlights have brought little attention to a very important problem—the estimation of radiation health effects. The prevention of such effects is the basis for plant safety decisions and the primary reason for the costly design and operational complexities that Flavin writes about. The probabilistic risk assessment work he mentions has involved considerable research to estimate the probabilities of accidentally bringing the contents of a reactor core into the public domain. This probabilistic risk assessment also involved the estimation of early and delayed health effects.

Although delayed cancer and genetic effects are considered to be random, the risk coefficients used in their calculation are given as constants rather than as probability functions. This practice eliminates consideration of the probability of zero effects, a highly significant probability at low doses for which the coefficients are highly uncertain. The most significant problem highlighted by Three Mile Island and Chernobyl may be the very real possibility that important decisions to be made about nuclear electric power could have a speculative technical basis.

Consider the highly influential word "catastrophic" as used by Flavin in reference to Chernobyl. Thirty-one workers lost their lives at the plant, and to these workers and their families the accident was catastrophic indeed. However, these tragedies happened on-site, where radiation dose rates were very high, rather than in the public domain. The doses received were so large that death intervened long before delayed effects had a chance to occur. Early effects (manifested within hours to months after doses exceeding about 100 rads) could happen to the public only if an accident much worse than Chernobyl were to occur.

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Melting of the core in a U.S. light-water reactor takes time; redundant detection systems provide early warning when such accidents begin, and failure of a containment building is a low-probability event. If evacuation within a two-mile radius of a nuclear plant is completed prior to any failure in the containment building, it appears that off-site radiation doses high enough to cause early fatalities would be prevented.

This outcome would also be expected if containment failure were to occur during the evacuation procedure. Early containment failure is associated with rapid pressure rise caused by intense heating of the containment atmosphere. Under these conditions fission-product release would result during depressurization of the building. An explosion of great force, worse than at Chernobyl, with an immediate release of fission products is not considered to be a major concern.

Flavin refers to a hydrogen explosion that "almost resulted" at Three Mile Island. Although hydrogen combustion might be able to cause failure of a containment building, the failure would not be expected to occur sooner than about two hours after the start of core melt, thereby allowing considerable warning time for taking protective actions. Thus predictions of delayed deaths from radiation-induced cancer seem to me to be the most significant consequence of a reactor accident in terms of impressions left with decision-makers. I suspect that these predictions are more likely to prompt the word "catastrophic" and to alarm decision-makers around the world.

Most of the Chernobyl estimates involve many thousands of fatalities in the Northern Hemisphere; for example, a recent study sponsored by the U.S. Department of Energy published an estimate of 28,000 fatalities (*1*). This report repeatedly states that it is possible that no delayed deaths will occur. However, decision-makers are more likely to remember the 28,000 theoretical estimates than the 31 actual fatalities on-site. There are reasons to believe that the calculational results may be too clouded by uncertainty to be useful. For example, the risk coefficients used are based primarily on an epidemiology study involving 54,000 atomic bomb survivors. This sample size provides statistically sound information only for doses exceeding 10 rads. Average lifetime doses in the Northern Hemisphere are given below.

The DOE report makes it clear that the Chernobyl dose determinations are highly uncertain, that very low lifetime doses would likely produce no additional radiological risk, and that there are no direct data confirming that a few random ionizations in tissue will cause fatal cancers. In consideration of these facts, the authors of the report included the following footnote to each table pre-

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senting latent cancer estimates: "The possibility of zero health effects at very low doses and dose rates cannot be excluded." This careful, scientifically sound wording is typical of the radiobiology literature. Unfortunately, these statements usually do not reach decision-makers, and they almost never reach the general public.

Many health physicists are dismayed by the now-common practice of including extremely low doses in health effects estimations. When doses obtained in this manner are multiplied by risk coefficients valid at best for doses exceeding 10 rads and dose rates exceeding 1 rad/yr, the results can be alarming and misleading, and they may have a detrimental influence on decision-makers. If individual doses below 10 rads and dose rates below 1 rad/yr for a lifetime are excluded from the 28,000 estimated cancer deaths, only the evacuees are affected and the theoretical result is 410.

To my mind, the consequences predicted for the evacuees are technically questionable. I would characterize estimates of the type indicated for European U.S.S.R. (0.63 rad average) and Europe (0.15 rad average) as conjecture. I find any estimate of the type made for Asiatic U.S.S.R. (0.005 rad average) to be speculation. Estimates of the type made for Asia (0.001 rad average) and the United States (0.0005 rad average) I would classify as pseudoscientific speculation. Although these characterizations are given as one health physicist's opinion, I should think they would be comforting to millions of exposed people who are needlessly worried.

In my opinion there is a very limited place for conjecture and speculation in science. Even hypotheses must always be clearly identified as such, particularly when the results of hypothetical calculations can reach unsuspecting legislators and agency heads, influencing their decision-making process in a manner detrimental to the best interests of the nation.

Flavin has studied nuclear plant safety and concludes that "there must be greater preparation for the consequence of the inevitable failures" and that "important reforms must be introduced soon." Perhaps he is right. But surely it is true that the expenditure of resources for these preparations and reforms must be commensurate with our knowledge of the risks and that those who make the final decisions regarding these preparations and reforms must be well informed regarding these risks. There is a larger picture that should be considered. The catastrophe that I am worried about is that the competitive position of America may be damaged by those who fear that the sky is falling.

"The possibility of zero health effects at very low doses and dose rates cannot be excluded."

References

(1) *Health and Environmental Consequences of the Chernobyl Nuclear Power Plant Accident;* Acquisition No. DE 87013578, National Technical Information Service: Springfield, Va., 1987; DOE/ER-0332.

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Numerical data for scientists

By Stephen R. Heller and Lewis H. Gevantman

The scientific community is currently undergoing phenomenal changes in the way it produces, compiles, and disseminates scientific information and data. Much of it can now be managed by computer. Similarly, bibliographic literature searching has become routine using a variety of on-line systems (see box).

A newer activity that is starting to make its presence felt in the scientific community is that of providing the scientist with access to numerical data through a variety of automated mechanisms. Several numerical data bases have emerged and are now being used.

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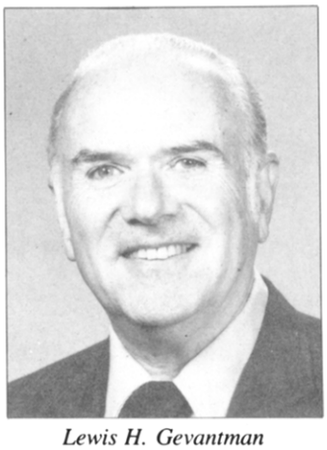

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