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Problems of Pollution: Benefits, Risks and Regulations

Richard E. Pogue
University of Minnesota

Dean E. Abrahamson
University of Minnesota

Benefits, Risks and Regulations

Richard E. Pogue * and Dean E. Abrahamson **

ABSTRACT — The growing concern of the scientific community and informed segments of the public about the proliferation of untested nuclear power plants demands further evaluation of their environmental impact before irrevocable decisions are made. This paper considers the problem of low-level radioactive wastes controllable at the source. A brief background is given of the governmental agencies concerned with radiation monitoring and protection. The underlying philosophy behind radiation protection and the guidelines for putting this philosophy into practice are considered. The risk implicit in these guidelines is assessed in terms of the expected increased incidence of specific injuries to human populations.

The environmental impact of a growing nuclear power industry is yet another example of the classic confrontation of risk versus benefit. The opposing forces are society's need for the products of technology and the public's health and welfare. With nuclear power, the benefits of using this form of energy to generate electricity must be balanced against the risk of continuous radioactive and thermal pollution of the environment, and the consequent effect on both humans and biological organisms. The possibility of a catastrophic accident to the nuclear reactor also must be considered, but that is remote, so this paper considers only the problems of low-level radiocative wastes controllable at the source.

The dichotomy of the problem shows up in the ambivalent attitudes of both industry and the anti-pollutionists. The power company says it is prepared to spend any amount necessary to protect public health and insure safety, but contends at the same time that the cost of environmental protection should not be considered an expense of generating power. On the other side, those concerned with air and water pollution from other sources see nuclear power plants alleviating the conventional problem but often seem unaware of the less obvious but potentially more dangerous radioactive pollution. It would indeed be ironic if man replaced one source of pollution with another more insidious and of greater long-range consequences.

The Statistical Magnitude

The magnitude of the problem of radioactive pollution is reflected by the number of reactors on order or planned for installation by 1980. (Hogerton, 1968). Nearly half of all new power generating capacity ordered in 1966 and 1967 was nuclear; by 1980 it is expected that nuclear power plants will account for about one-third of the nation's total generating capacity. In Minnesota, the difficulty is compounded by the relatively small river into which discharge will be made, by location of plants close to the state's major population center, and by ramifications of the effect on the entire river system downstream. There is, however, an opportunity to prevent a dangerous pollution problem before it occurs, rather than having to cope with air and streams already severely burdened as with other pollutants.

As background for the emerging public discussion of radiation protection, knowledge of the agencies involved, and their relationship and competency is required.

Responsibility for the development of a national atomic energy program was given to the Atomic Energy Commission (AEC) in 1947 by Congress. The AEC has actively promoted development of a national nuclear power capability by supporting research activities and technical development, and by providing monetary incentives (Hogerton, 1968). Congress also has given the Atomic Energy Commission sole authority to review reactor designs and sites, and to license reactors.

The Atomic Energy Act of 1954 included a pre-emption statement explicitly stating that its intent was to remove jurisdiction over radiation hazards from the states and give it to the AEC. A 1959 amendment to this act deleted the pre-emption statement, apparently because of concern about its constitutionality in abrogating the fundamental right of the states to control the health, safety, and welfare of their citizens (Dunnington, 1967). At present this question remains unresolved, but Minnesota state agencies seem to feel that their authority to set radiation standards is firmly established.

The role of the U.S. Public Health Service appears to be solely advisory. Weaver and Stigall of the Public Health Service state that the primary function of the Nuclear Facilities Environmental Analysis Section of the Public Health Service "is to provide technical assistance and consultation services to the states . . . If, in the course of the technical review, apparent design anomalies or specific technical deficiencies are noted, these factors are called to the attention of the AEC's review staff . . ." (Weaver and Stigall, 1967). The Public Health Service seemingly has no authority to force modification of design, and its recommendations can be ignored by the AEC.

This structure of authority and responsibility seems inherently dangerous for the public health and welfare. On the one hand the Atomic Energy Commission is

*Richard E. Pogue is an Assistant Professor of Biometry in the College of Medical Sciences at the University of Minnesota. He received his B. A. in Zoology and Chemistry at the University of Minnesota in 1952, and his Ph.D. in Biostatistics at the University of Minnesota in 1966, and has been on the staff of the Biomedical Data Processing Unit since 1965.

**Dean Edwin Abrahamson is Assistant Professor of Anatomy in the College of Medical Sciences at the University of Minnesota. He received his B.S. in Physics and Mathematics from Gustavus Adolphus College, St. Peter, Minnesota, in 1955, and his M.A. in Physics from the University of Nebraska in 1958. In 1967, he earned his Ph.D. in anatomy and M.D. from the University of Minnesota.

charged with actively promoting the development and use of atomic power, and on the other it has responsibility for the integrity of the total ecology. A potential conflict of emphasis clearly exists.

When the balance between benefit and risk involves as many judgmental factors as with nuclear power, it would seem far better to have the environmental impact evaluated by separate agencies with special competency in each environmental area, and to allow open discussion of differences.

State Responsibility and Capability

The question of the federal-state relationship also needs careful examination. In a recent article in the American Journal of Public Health, Dunnington[1] (Dunnington, 1967) suggested that whether states do indeed have authority to set radiation standards is at present almost irrelevant, because no state is yet fully capable of accepting responsibility for nuclear facilities. Whether states should attempt to become capable of evaluating reactor safety seems doubtful, and the responsibility to safeguard against catastrophic accidents should probably remain with the AEC. The states must, however, become capable of evaluating all aspects of discharge of wastes if they are to retain control over their local situation. There seems little reason to believe that Minnesota is presently capable of accepting this responsibility.

Responsibility for providing a federal policy on human radiation exposure rests with the Federal Radiation Council established in 1958. The members of this council are the Secretaries of Health, Education and Welfare, Agriculture, Commerce, Defense, and Labor, and the chairman of the Atomic Energy Commission. Under its statuatory authority, Federal Radiation standards ". . . may be exceeded only after the Federal agency having jurisdiction over the matter has carefully considered the reason for doing so . . ." (FRC Report No. 1, 1960).

The evolution and philosophy behind radiation protection guidelines is summarized in Reports 1, 2 and 5 of the Federal Radiation Council (1959, 1961, 1964). The fundamental scientific question underlying radiation exposure guidelines is whether there exists a threshold radiation dose below which no biological effects occur. If so, protection could be provided by setting standards below that dosage level. The radiation threshold view was accepted on the basis of early clinical information, but as data has accumulated, the threshold has been revised downward until its very existence is in doubt.

The difficulty in evaluating radiation thresholds is that little data is available as to effects of low radiation doses over long periods of time. Most existing evidence has been obtained from follow-up of survivors of atomic bomb blasts, from therapeutic uses of radiation, from occupational data involving radiation exposure, and from animal experimentation. Meaningful investigation of low doses requires experimenting with large numbers of subjects through successive generations if both somatic and genetic effects are to be evaluated. The problem of extrapolating from animal to human populations also exists, since experimentation on humans is obviously impossible under conditions outlined above. It therefore seems unlikely that precise quantification of the effects of low-level radiation will be possible in the foreseeable future (ICRP Publication 8, 1965:56). In the light of all this, the Federal Radiation Council has adopted the prudent assumption that a threshold radiation dose does not exist, and that ". . . every use of radiation involves the possibility of some biological risk either to the individual or his descendents" (FRC Report No. 1, 1960).

In this situation it becomes necessary to strike a balance between benefit and risk, between unnecessary restriction of nuclar power and minimal risk to the population. The problem is no longer simply a scientific question. Three distinct factors play a part in the resolution of the problem: (1) the scientific determination of the risk of human injury associated with a given exposure, (2) the technical determination of the benefit to be received from the use of nuclear energy, and (3) the social and political decision of how many cases of leukemia, cancer, and genetic damage the society is willing to accept for the benefits from a specific use of nuclear energy. With regard to nuclear power plants, a hasty answer might be that no human loss is acceptable. A more rational question, however, is what restrictions should be placed on the discharge of wastes into the environment, weighing the costs of these requirements against the gain in human protection.

A major criticism of the Federal Radiation Council is that its standards have been established in executive orders without open public discussion of risk and benefit (Frost, 1965). Even granting that discussion of radiation standards is seriously hampered by the lack of information, many people feel that delegation of important social and political decisions to a panel of experts within the executive branch is contrary to the public interest.

Guidelines for Protection

Radiation standards established by the Federal Radiation Council are expressed as Radiation Protection Guides, defined as the "dose which should not be exceeded without careful consideration of the reasons." Different dose levels are established for radiation workers and for the general population, for whole body exposure and for various organs in the body, and for different exposure times. The basic guide for an individual in the population is .5 rem whole body exposure per year above natural background and excluding therapeutic uses, with a maximum exposure to the gonads of 5 rem over thirty years. As an operational technique when individual whole body dose is unknown, a guide of .17 rem per year is applied. These values may be compared with natural background radioactivity of .08-.17 rem in most places on the earth, man-made non-environmental sources of .08-.28 rem, and fallout from nuclear explosions. This is generally less than .1 rem. although by 1964 the inhabitants of arctic Alaska had been exposed to a dose of about .4 rem from fallout (FRC Report No. 6, 1964). The amount of radioactive discharge per-

[1] Dunnington is chairman of the New Jersey Commission on Radiation Protection and professor of physics and radiation science, Rutgers, the State University, New Brunswick, N.J.

mitted from nuclear power plants should take into account that modern man is exposing himself to additional man-made radioactivity somewhat greater than that to which he has adapted himself through the centuries. A lower standard would clearly seem more appropriate, especially since the only cost is a slightly higher cost for electricity.

Another concept introduced by the Federal Radiation Council is that of a Radioactive Concentration Guide, defined as "the concentration of radioactivity in the environment which is determined to result in whole body or organ doses equal to the Radiation Protection Guide." After a Radiation Protection Guide is established, a concentration can be established for each radioisotope in the environment against which to compare observed concentrations. However, since an individual is usually exposed to more than one radionuclide, reliance on Radiation Concentration Guides could allow an individual to receive a total dose greater than the Radiation Protection Guide even though each radionuclide was within its concentration limit. This fallacy is promoted in the concentration limits set by the Atomic Energy Commission in its regulation 10CFR20. Reliance on concentration guides also ignores the presence of more sensitive targets such as the fetus, and cannot take into account the concentration of radionuclides through the food chain to man.

In the absence of a Federal Radiation Council statement of the risk contained in its standard of .5 rem, one may turn to Publication No. 8 of the International Commission on Radiological Protection (1966). A task group was set up in 1964 "to consider the extent to which the magnitude of somatic and genetic risks associated with exposure to radiation can be evaluated." Estimates are expressed as the number of cases of a specific injury type to be expected from the exposure of a specified number of people to a given radiation dose. Because of the imprecision inherent in the data, upper and lower bounds on the number of injuries to be expected are given rather than a single number. If we assume the population of the Twin Cities metropolitan area to be two million, then a continuing yearly exposure of .5 rem — the FRC standards dose — would be expected to cause from 10 to 100 cases of leukemia per year and about an equal number of other types of neoplasms. Estimates of the genetic damage from this dose are also available. Whether a loss of this magnitude is acceptable to society can only be determined by considering the benefits to be gained from a particular use of atomic energy. The Federal Radiation Council has given no indication of the uses of atomic energy for which *it* feels a loss of this magnitude is acceptable.

It appears unlikely that any single nuclear power plant will discharge sufficient radioactive waste to reach the FRC standard, even if the standard were revised to take into account existing man-made radioactivity.

Conclusion: Open Discussion Necessary

The nuclear power industry is still in its infancy, however, and little operational experience has yet been gained with the present generation of reactors. Indeed the Atomic Energy Commission has felt compelled to point out that it is unwarranted to ask the board to deal only with new features of reactor design because "the new features in these cases are not departures from established standards but from other reactors whose 'old' features remain in many cases untested."

What is wise public policy in this case, especially with so many untested reactors to be installed within a short period of time? The growing concern of both the scientific community and informed segments of the public demands that the problems associated with nuclear power — and indeed all peaceful uses of atomic energy — be subject to open discussion and further evaluation before irrevocable decisions are made.

Discharge of Radioactive and Thermal Wastes

ABRAHAMSON AND POGUE

ABSTRACT — A combination of several economic factors, together with growing concern about air pollution associated with conventional, fossil-fuel electric generating facilities, has contributed to the increase in size and number of nuclear-powered plants. Although these nuclear plants are "clean" from the standpoint of conventional air pollutants, they must dispose of thermal and radioactive wastes. This paper outlines the sources and quantities of these wastes, based on technical data for the boiling-water reactor proposed for Monticello, Minnesota.

Total electrical power production is expected to about double in the next ten years, with the biggest part of the increase coming from nuclear plants (U.S. Atomic Energy Commission, 1967).

A nuclear generating plant, Figure 1, is schematically similar to a conventional steam plant. Exceptions are that the heat source — the reactor core — depends on the fission reaction in uranium, and the wastes are radioactive fission and activation products. The waste heat from a nuclear plant also is considerably greater than from a conventional plant of the same generating capacity.

Heat is generated in the reactor core and is transferred to a primary coolant, usually water, surrounding the core. This water is heated, converted to steam and passes through a pipe to operate the turbine-generator. The water is then recondensed and pumped back into the primary reactor vessel to complete the primary coolant loop. In some reactors there is an intermediate heat-exchanger