BENEFITS AND RISKS TO NUCLEAR POWER IN THE UNITED STATES OF THE "AS LOW AS PRACTICABLE" PHILOSOPHY

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At the outset I should apologize to this group for the somewhat laborious title of this presentation. It resulted from a somewhat hasty consideration on my part of a title for the subject matter which I would like to present today; an attempt to communicate to you some of the difficulties that have been created in the United States by the enthusiastic application of the philosophy with which we in the radiation protection field have been living for several decades at least.

However, in attempting to present at least one individual's view of these problems, I am confronted with several difficulties, particularly for a distinguished international audience. One of these difficulties is created by the innate complexity of the agencies, organizations, and entities involved in U.S. radiation protection programs, as well as their assorted guides, standards, and regulations which apply in varying degrees to nuclear facilities. A second difficulty is established by attempting to relate the significance of other non-radiological laws, court decisions, and agency actions on radiological as well as non-radiological issues.

In the first area, we are involved with recommendations, evaluations, guides, standards, and regulations which at one time or another have been promulgated by the National Council on Radiation Protection and Measurements, the Federal Radiation Council, the National Academy of Sciences, the Environmental Protection Agency, and the Atomic Energy Commission, to say nothing of the influences exerted by the United Nations' Scientific Committee on Effects of Atomic Radiation and, of course, the International Commission on Radiological Protection, both of which have had a substantial influence on U.S. policies and practices in the radiation protection field. In the second instance of difficulty, we need only to look at the effects of the National Environmental Policy Act, or NEPA, and several judicial decisions about its interpretation to identify the significant impact these have had on radiological protection aspects of nuclear power, as well as on other non-radiological aspects of these facilities.

In this presentation, I would like to describe the potential threats as I see them to the viability of the generation of energy from nuclear sources in the U.S. which owe at least as much to the application of the "as low as practicable" philosophy as to any other source. It is these somewhat perhaps overzealous applications of the concept in the U.S. that I would like to explore this morning in the hope perhaps that other nations may avoid some of the pitfalls we appear to be creating in our own country.

Much of the zeal exhibited within the past few years has derived from efforts to reclaim the environment in general from a number of misapplications of technology which have resulted in the degradation of significant portions of our environment. At the same time and as part of the same movement, an intensive examination has been initiated of those environmental factors, whether natural or man-made, which may have more subtle effects on human health and welfare now that modern medicine and public health engineering have generally extended our life spans by eliminating, at least in large measure, the more obvious communicable diseases.

For the nuclear community, one of the more significant controversies over the past few years has been about the issue of radiation exposures deriving from the operation of commercial nuclear power plants. Certainly the names of Drs. Gofman, Tamplin, and Sternglass can evoke very predictable responses from those members of the nuclear community whose operations or plants have been affected by that controversy.

Additionally, the National Environmental Policy Act, as interpreted by the courts, has stimulated a broad inquiry into all other aspects of potential environmental impact with the objective of achieving a balance between benefits and costs, both economic and environmental. In many cases, however, pressures have been directed toward eliminating environmental effects regardless of cost or of the significance of the effect. In some of these instances, however, the application of a narrowly-focused effort to minimize one effect has created other, more significant effects.

As a quite recent, if peripheral example, I would cite a news article this weekend that quoted a scientist with the Environmental Protection Agency's Air Program research activity to the effect that catalytic devices proposed for removal of pollutants from automobile exhausts might in fact themselves discharge more harmful particulates of sulfuric acid and platinum.

More significant to the nuclear power industry (an in fact to the power industry in general) is the legislative goal of eliminating all discharges to waterways within 10 years. Although the guidelines for power plants are not yet promulgated, preliminary manifestations of the EPA policy are already evident. Actions in individual power plant cases, as well as a draft report on feasible technology, strongly suggest a mandate of closed cycle cooling using evaporative cooling towers for power plants regardless of site. Thus, "as low as practicable" may well become "as low as possible" in the water--with such potential adverse side effects as salt drift and deposition at coastal sites, evaporative depletion of fresh water resources in water-short areas, fogging and, in colder climates, icing of structures and roads. However, since these are not <u>water pollution</u> problems, they appear not to have been considered.

We have our own example of this type of "tunnel-vision" in the radiation protection field, however, and it is on this issue I would like to concentrate. It is related to the perspectives presented by Dr. Lapp yesterday--but presents still another aspect of considerable signficance.

It is probably entirely superfluous to remind this audience that the ICRP, in 1950, stated: "It is strongly recommended that every effort be made to reduce exposures to all types of ionizing radiations to the lowest possible level." Although this injunction was directed primarily at occupational exposures, it did reaffirm for the radiation protection community the principle of minimizing exposure. In 1954 and again in 1957, the NCRP recommended that "exposure to radiation be kept at the lowest practicable level in all cases." In the 1957

statement, NCRP also made recommendations for the limitation of exposure to individuals outside of "controlled areas," as well as for population exposure.

Although the recommendations of the ICRP and NCRP were widely adopted by operating organizations, these recommendations as such carried no statutory force. To provide a federal policy in the U.S. for human radiation exposure, the Federal Radiation Council was formed in 1959 to "advise the President with respect to radiation matters directly or indirectly affecting health." In 1960, the first report and recommendation by the Federal Radiation Council staff essentially adopted the recommendations of the ICRP and NCRP, but selected the term "radiation protection guide" for the "maximum permissible dose" concepts of the other organizations. Again the staff report stated: "Every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable."

During the 1950's and 1960's the Atomic Energy Commission, which provided the regulatory control over all major nuclear activities, had adopted its own radiation protection standards. These were in two forms: the first, a codified section of the Code of Federal Regulations, the so-called Part 20, applicable to licensees of the Atomic Energy Commission; and the other, a portion of the AEC manual appropriate for internal operations of the AEC and its contractors at such facilities as Oak Ridge, Hanford, Savannah River, etc. It is, of course, Part 20 of the AEC regulations that apply to the nuclear power facilities that are being built and operated by electric utility companies in the U.S.

In 1968 and 1969, substantial controversies were generated in the U.S. by a number of individuals with respect to the projected effects of exposure of populations to doses from nuclear plant operations at the limits prescribed by FRC guides for the population at large. Needless to say, the allegations by Gofman and Tamplin created a widespread controversy not only in the United States but elsewhere as well. Although these allegations were refuted at the time and more convincingly since by BEIR, one of the difficulties in dealing with them derived from the fact that Part 20 of the AEC regulations dealing with licensed facilities nowhere explicitly included the ICRP/NCRP/FRC recommendation that exposures be maintained at the minimum practicable value.

I pointed this out in testimony before the Joint Committee on Atomic Energy in January 1970, although I indicated then that in practice the Regulatory Staff of the Atomic Energy Commission had in fact applied that philosophy in their review and approval of facilities seeking permits and licenses. In April of 1970, the AEC proposed amendments to their regulations which would include the "as low as practicable" mandate in the Part 20 standards. Additionally, AEC proposed amendments to that section of their regulations covering licensing of nuclear facilities* which would require applicants to identify the design objectives for discharges and the means to be employed to keep discharges as low as practicable, as well as a requirement for operating plants that equipment installed in effluent management systems be maintained and used to assure that discharges were as low as practicable.

At that time, the Commission indicated its plans to consult with the industry and with other interested groups and persons to determine the feasibility of developing more definitive criteria for the design objectives and the means for keeping radioactive discharges from light-water-cooled nuclear plants as as low as practicable. The proposed amendments to Part 20 and Part 50 were

* Part 50

adopted in December of 1970, and early in 1971 the AEC carried out its announced intention to meet with industrial and other representatives to review the feasibility of establishing more definitive numerical guides. In December of 1970 also, a reorganization of part of the Federal establishment transferred the functions of the Federal Radiation Council to the newly established Environmental Protection Agency.

In June of 1971, the Atomic Energy Commission issued for comment a proposed Appendix I to their regulations for licensing of nuclear facilities which established numerical guides for design objectives and limiting conditions for operation governing discharges of radioactive materials in effluents from light-water-cooled nuclear power plants. These were intended to implement the "as low as practicable" concept and basically provided for discharge limits which would result in exposures 1% of the ICRP/NCRP/FRC recommendations for individuals in uncontrolled areas, or 5 millirem per year. The position of the Regulatory Staff was that the discharges reported for existing plants indicated the general feasibility of meeting these new lower limits at modest expense and that the values needed to be in that range in order to protect the public health and safety as nuclear power became a more significant contributor to both electric generating capability of the United States and to the dose to the population of the United States.

A very large number of comments were received from utility organizations, from reactor manufacturers, from architect-engineers, from consultants, from environmentalists, and from other government agencies, and predictably enough ranged from the viewpoint that the guides were unnecessarily restrictive to the opposite.

A rulemaking hearing was held during the first five months of 1972 with participation by a combined group of utilities, by a reactor manufacturer, by a consolidated group of environmental intervenors, and by the State of Minnesota. During the course of these rulemaking hearings, several factors became apparent. The first, and perhaps most important, was the intention of the Regulatory Staff to apply the same degree of conservatism in arriving at projections of radioactive releases and in assessing the resulting doses as had been applied when the standards were greater by two orders of magnitude. In particular, it was proposed to include not only normal waste releases but also those that might result from off-standard operation, so-called miscellaneous leakages. Few if any of these had been measured and reported by the operating plants, so the basis on which the practicability of meeting the new guide had presumably been demonstrated was immediately in question. In the dose assessment area, perhaps the most notable of the Staff conservatisms became the "hypothetical future cow" which was to be assumed to be chained to the nearest site fencepost, with an infant permanently attached to its hind leg, even if such farming uses did not exist in the present or foreseeable future.

It appeared obvious to several of us who participated in that hearing that the Staff had not really done its homework in evaluating the impact of their proposed rule either in terms of costs of compliance in an economic sense or with the benefit to be obtained as a result of these costs. One of the AEC's own biomedical witnesses, Dr. Leonard Sagan, indicated that in his view the expenditures required for meeting these proposed limits might better be spent in controlling and reducing exposures of the public from X-ray machines. I think Ralph Nader might even agree with that position if he had better advisers than John Gofman. In the instance of the proposed limit for radioactive iodines, the combined utility group produced testimony which indicated that it was highly unlikely that the proposed limit was even feasible to

achieve, particularly under the assessment ground rules established by the licensing Staff, and that the costs of compliance with the proposed rule could reach very large figures very easily.

Even the environmentalist intervenor group witnesses, with the exception of Dr. Sternglass, generally supported higher radiation exposure limits than those proposed by the AEC. A final point, and one which I will expand on a little later, was made by the combined utility group--that the staff had given no consideration to the potential increase in plant worker exposure which might result from the adoption of these more stringent restrictions on releases from the plant.

At the end of the hearing in May of 1972, the AEC announced that it would prepare and issue an Environmental Statement on the proposed rule to assess the costs and benefits of its implementation and to consider alternatives to the proposed rule. This Environmental Statement was an outgrowth of the requirements of the National Environmental Policy Act that any Federal action having a significant impact on the environment must be preceded by an environmental statement which examines the costs, benefits, and alternatives to the proposed Federal action. The Draft Environmental Statement was issued for comment in January 1973.

The direction and scope of the Draft Environmental Statement tended to support the view of some individuals that the AEC decision to establish 1% of the NCRP limits as a design objective may not have been as much technically motivated, but rather politically stimulated by a desire to silence their critics. The Draft Statement was a fairly substantial exercise in numerical calculations which attempted to demonstrate by the sheer weight of numbers that the 5 millirem per year dose objective was indeed achievable although at some cost. It did not, for example, consider in any real sense alternatives to the proposed numerical guidance of 5 millirem per year. It appeared in summary to be a massive exercise in self-justification.

The methodolgy employed in the Draft Statement was to establish models of boiling water and pressurized water reactors; to hypothesize radioactivity releases from these plants using alternative waste treatment schemes which started with the base cases being essentially open sewers; to establish these hypothetical plants in so-called representative sites; and to assess the doses to individuals and to populations resulting from the hypothesized releases from alternative waste processing schemes. Estimates were made of the costs of these additional waste systems and the differential costs associated with the resultant reduced exposures.

In these assessments, many of the same conservatisms employed by the Regulatory Staff in individual plant licensing actions were largely reiterated. Normal operation was assumed to include a wide variety of off-standard operations, including fluid leakages, fuel failures, etc., which resulted in a tendency, as the statement indicated, "to overestimate the quantity of radioactive material released in the effluents."

To determine the impact of these releases on hypothetical individuals and population groups around these hypothesized plants, a number of interesting characteristics were ascribed to the so-called maximum individual. This individual was used to represent the "maximum" dose which could be postulated for an individual in the station environs. This in itself was at variance with the stated intent of Appendix I to deal with "expected" rather than maximum situations. "The individual is assumed to have been conceived, born, and expected to live his entire lifetime on a farm adjacent to the station site boundary. He is assumed to eat nominal amounts of fish,

crustacea, mollusks, and acquatic vegetation (if applicable) taken from near the outfall of the liquid effluent; to obtain his drinking water from near the site boundary (for sites adjacent to fresh water); to swim and boat in the waterway near the outfall; to engage in normal recreational activities on the shoreline near the station; to eat fresh green vegetables grown on the farm; and to drink fresh milk obtained from cows on local pasture. Further, the farm is assumed to be located in the sector downwind of the predominant wind direction."

From the numerical attributes assigned to this individual in the Draft Environmental Statement, he was truly heroic. He ingested two and one-half times as much fluid as does the ICRP standard man; he ate as much seafood annually as does a commercial fisherman, except near the sea coast site where he ate twice as much seafood as does a U.S. commercial fisherman; he also spent 500 hours per year on the shoreline near the plant outfall, and 200 hours more swimming or boating near the outfall, presumably to catch all the fish he eats. At the same time, he survived largely on spinach, lettuce, and cabbage grown in the most exposed off-site area in an amount equal to half the U.S. average total annual vegetable intake, and drank about three times as much milk from his own cow (presumably pastured in the vegetable patch) as does the average individual in the U.S., while simultaneously remaining naked all year 'round on the downwind fencepost next to the cow. Sometime during this period, he also found time to arrange for a new infant every year. While the concept of the critical population group is not a new one in the radiation protection field, this exercise did appear to be advancing the state of that art by a substantial amount.

Having gone through this exercise, the Draft Environmental Statement came to the conclusion that with the exception of radioactive iodines, it appeared feasible and not economically unreasonable to achieve the design objective of 5 millirem per year. However, in order to achieve this design objective for radioactive iodine discharges, it would have appeared to be necessary to exhaust all ventilation air flows from turbine, auxiliary, and reactor buildings through perhaps a thousand high efficiency filters and charcoal absorbers units and 100 meter tall stacks. Since there are a large number of plants which are being designed and built in the U.S. under the apparent misconception that "clean nuclear power" does not require chimneys, this came as somewhat of a shock.

In fact, the Draft Environmental Statement confirmed what the combined utility group had stated during the hearing; e.g., there did not seem to be any biological rationale for the dose objective of 5 millirem per year and, in any event, it appeared highly infeasible to assure meeting the restrictions on release of radioactive iodine. What was not considered in the Draft Environmental Statement was the necessity for meeting the proposed guideline for that substance let alone for the other discharges.

The costs of achieving the desired degree of protection were not insignificant even if the estimates made on behalf of the AEC were accepted at face value. These estimates indicated that the annual incremental costs for control of radioiodines might range between $500,000 and $1,000,000 per year for pressurized water reactors and between $1,000,000 and $2,000,000 per year for boiling water reactors for such control. Needless to say, one could buy significant amounts of land or cows or liters of milk for that annual cost. It was suspected, in addition, that the costs of control contained in the Draft Environmental Statement were low perhaps by as much as a factor of two.

Despite the information introduced in the hearing by the utilities, not one word appeared in the Draft Environmental Statement about the potential impact on in-plant personnel exposures resulting from the adoption of the proposed rule, nor was any consideration given to those facilities which might incorporate more than two units per site.

Over three hundred pages of comments on the Draft Environmental Statement were filed, the bulk of which were critical of the approach and the substance of the Draft Environmental Statement. Late in July of this year, the Final Environmental Statement was published by the AEC. It is substantially bulkier but not significantly better than the Draft Statement. The Final Environmental Statement consists of three volumes: the first of which is the Statement itself; the second, a description of the analytical models and calculations employed; and the third, a compendium of comments and the responses of the Staff to those comments.

Many, if not most, of the deficiencies in the Draft Environmental Statement remain. No significant consideration has been given to the costs and risks of a guideline higher than 5 millirem per year; the conservatism in estimation of source terms for releases from plants has been maintained in much the same form as in the original draft statement; the heroic proportions of the so-called maximum individual are essentially unchanged from those in the Draft Statement, although at least a step in the direction of assuming more reasonable parameters for the population at large has been taken for estimation of population dose; the cost figures used by the Staff in the Final Environmental Statement appear to be about a factor of two lower than the cost estimates for comparable pieces of equipment in the Draft Environmental Statement (the original estimates were felt perhaps to be low by as much as a factor of two).

There has been some relaxation of the attitude of the Regulatory Staff in respect to the potential capabilities to deal with radioactive iodine. The Final Environmental Statement does indicate that perhaps the 5 millirem per year objective is not a practically achievable limit at this time, and the figure of 15 millirem earlier produced in an Atomic Energy Commission Safety Guide is presented as a potential alternative for the initially proposed value.

However, in my view, the document still neglects a major consideration in the cost-benefit balancing that needs to be done prior to the adoption of these extremely stringent limits on discharges. In the Draft Statement, the AEC recognized the values of dollar cost per man-rem of exposure that have been assigned by a number of authorities over the years. (Dr. Lapp yesterday mentioned $60 per man-rem, for example.) It, perhaps understandably, chooses not to balance directly the costs of systems to provide a man-rem reduction against the value of the man-rems so saved, although in a number of instances the ratio between the cost of saving a man-rem and the highest value that might be assigned to it are so far out of balance that the expenditures must be regarded as nonsensical. There is one area, however, in which a direct comparison could have been attempted but was not. This area is the one to which I referred earlier and about which a number of comments were made by those who reviewed and commented on both the initial Appendix I and the Draft Environmental Statement. I refer here to the potential impact on occupational exposures. There is no treatment of occupational exposure impact whatsoever in the Final Environmental Statement, despite the evidence put forth in the hearing itself, the comments made on the Draft Environmental Statement, and in fact comments and findings made by at least one Atomic Safety and Licensing Board and an Appeal Board.

In one power plant licensing case in which the Staff evaluation deliberately excluded the dose received by on-site personnel, the Licensing Board stated, "Since the significance (if any) of general population exposure at these low levels lies in the impact on the gene pool of the entire population rather than in its relatively trivial somatic effects, from the point of view of the cost-benefit analysis, the environmental cost of the total genetic dose received by the entire population (including employees) is the important factor. The genetic dose to employees should not be considered as a voluntary occupational exposure, but rather as a dose to future generations and, therefore, fully comparable to the dose to non-employees." The Appeal Board in that case added the following: "We would add to these observations only the obvious fact that the more stringent the limitation on liquid and gaseous emissions from the facility, the greater the radiation exposure likely to be experienced by on-site plant personnel. Thus, a concomitant of undue conservatisms in the matter of computation of off-site emissions may be the subjection of the plant personnel to an unnecessary genetic dosage."

The growing significance of occupational exposure to operating and maintenance personnel at nuclear power facilities has been the subject of a number of papers over the past few years. We identified this problem in 1971 presentations based on data from a number of our clients, and others. Its growing significance has been attested to by the incorporation in the 1972 report of UNSCEAR of the doses from occupational exposure at nuclear power plants around the world. For these data which cover twenty stations with a gross electrical output of almost 19,000 megawatt-years, the average person-rads per MWe-year is almost 1 with a range of 0.2 to 8.9 man-rads per megawatt-year.

We have examined film badge exposure records of utility staff and contractors employed at nuclear power stations in the U.S. This analysis has treated 13 operating stations of the light-water type which have generated some 12,870 megawatt-years of electric energy and in the process reported total man-rem external exposures of over 18,000 man-rem, an average of about 1.4 man-rem per megawatt-year of electric energy. For these light-water plants, the range of exposure has been between 0.12 man-rem per megawatt-year and 4.5 man-rem per megawatt-year. Generally, the higher values tend to be associated with the older, smaller plants although this is not universally the case. The lower end of the spectrum tends to represent the newer, larger plants which have been operating only for one to two years and have not undergone either refueling or significant major maintenance activities which tend to substantially increase the total man-rem exposure.

Although it has not been possible at the present time in more than a very few cases to identify man-rem exposures associated with particular jobs at a representative number of nuclear power plants, the data that are available indicate that the overwhelming majority of the accumulated exposure derives from activities carried on during the refueling and major maintenance periods at these reactors. In any event, it is quite difficult to relate particular job exposures to potential requirements for maintenance work on systems demanded by the Appendix I requirements. It is not difficult, however, to extrapolate some of the job exposures that have already been reported to the potential requirements of implementing the "as low as practicable" policy of the Regulatory Staff and to observe intuitively the great <u>disbenefit</u> that is quite likely to accrue as a result.

For example, typical values of exposure for specific operating and maintenance items have been reported by some operating nuclear power plants. At one plant, for example, it was reported that, exclusive of supervision or technician assistance, the removal of spent demineralizer resins for shipment

involved an exposure of 4.8 man-rem. This would certainly be a more frequent occurrence under the expanded systems proposed to meet the requirements of the "as low as practicable" limits. The sipping or sampling of fifty fuel bundles for the detection of leaky fuel elements, which would almost certainly be required more frequently under the "as low as practicable" restrictions, at one plant produced an integrated exposure of 9.6 man-rem. The changing of waste filter cartridge units yielded an exposure of 0.2 man-rem. Doses accumulated during the inspection and repair of steam generators have ranged from a low of about 9 man-rem to a high in excess of 350 man-rem. In most, if not all these cases, the basic motivation for repair of the steam generator rested in the inability to comply with discharge limitations with continued primary-to-secondary leakage although in no case would population exposure to the public have been contributed which was remotely equivalent to that generated in-plant by the inspection and repair operations.

It is somewhat discouraging to me that it was only a few months ago, in April of this year, the Regulatory Staff began to request man-rem occupational exposure data from plant operators by job function. Considering the significance of these data, it seems hardly logical to have proceeded with the establishment of discharge standards in their absence.

No doubt much can be done to improve the ease and safety with which maintenance activities can be conducted, although for many of the maintenance jobs required, substantial reductions could only be accomplished by a significant change in the way nuclear plants are currently designed to one more closely resembling the fuel recovery plants in which remote maintenance activities are standard. Failing this, it does not appear as though substantial reductions in occupational exposure are likely to result from improved shielding, for example, or other similar plant modifications. Much of the equipment requires direct contact for maintenance and replacement of parts which cannot conveniently be performed in any other way.

On this basis and projecting the current experience in the U.S., it appears to me that the occupational contribution to the population genetic burden from nuclear power plants alone will substantially outweigh the general population contribution to that total by factors approaching two orders of magnitude. If you recall, ICRP suggested in 1958 in its illustrative apportionment of genetic dose that the exposure of the population at large might be twice as great a contribution to overall population exposure as would the occupational contribution.

The AEC has estimated that by the year 2000, light-water-reactors will provide a capability for generating 500,000 megawatts of electric power. Assuming a capacity factor of 80%, in that year a total of 400,000 megawatt-years of electric energy would be generated, and projecting current occupational exposure experience, this would result in a population exposure from this source of about 560,000 man-rems or almost 2 millirem per capita in that year. On the other hand, the Atomic Energy Commission in their Final Environmental Statement projects a population exposure from the operation of these plants of 24,900 man-rem, less than 0.08 millirem per capita-year, or 0.06 man-rem per megawatt-year. An examination of assessments by the AEC in their Environmental Statements for some 35 individual nuclear plants totalling 56,580 megawatts of capacity, yields a total projection of 728 man-rem per year or about 0.016 man-rem per megawatt-year (at 80% capacity) for these plants.

Given the conservatism inherent in the Staff analyses of population dose with respect both to transport and uptake, the ratio between occupational and the general public contributions to population exposure of between

20 and 90 can probably be increased by at least a factor of 2 to 3. However, accepting even that range of about 20 - 90 as it stands, it seems to me that there is a serious deficiency in any approach to reduction of environmental exposure standards of this magnitude without providing at least equal attention to the potential hazards of the trade-off that almost certainly will occur as a result.

Certainly the in-plant staff exposures are real and, on average, substantially higher than those to which even the nearest neighbors of nuclear plants have been exposed to in the past or are likely to be exposed in the future. Exposures, which have been experienced by neighbors to the plant, on the other hand, have been essentially invisible when compared to the natural background in the area. Under the new policy, these would be even more theorectical than real and the resulting population exposures would also be hypothetical rather than genuine exposures. It seems to me, then, that we are facing a trade-off of an increase in real, measurable exposures for an invisible decrease in hypothetical exposures, one which does not comport well with the basic radiation protection philosophies, at least those with which I am familiar.

While the Atomic Energy Commission has been vigorously defending its proposal to limit these releases from light-water plants, the National Academy of Sciences' Advisory Committee on the Biological Effects of Ionizing Radiation has been assembling an analysis of current knowledge relating to risks from exposure to ionizing radiation. This was published in November, 1972, and some extracts from this report, which was extensively discussed yesterday, provide an interesting counterpoint to the performances of the Atomic Energy Commission. Several of the recommendations of the BEIR Committee and their conclusions are of interest, particularly when examined in the context of the present controversy. I would like to quote some of these recommendations and conclusions.

> "It is suggested that numerical radiation standards be considered for each major type of radiation exposure based on the results of cost-benefit analysis."
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> "In addition to individual and average population guidelines, we recommend that an additional limitation be formulated... that takes into account the product of the radiation exposure and the number of persons exposed; this might be expressed in terms of person-rems. This need arises from acceptance of the non-threshold approach in risk estimates which implies that absolute harm in the population will be related to such a product."
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> "Guidance for the nuclear power industry should be established on the basis of cost-benefit analysis, particularly taking into account the total biological and environmental risks of the various options available and the cost-effectiveness of reducing these risks."
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> "Thus we say: The total future cost of one man-rem, in terms of health costs paid for in present dollars, is between $12 and $120. This may provide one way for putting a dollar value on a dose commitment of one rem that could be used in cost-benefit calculations. The cost would be distributed over many generations in the future."
>
> "The public must be protected from radiation but not to the extent that the degree of protection provided results in the substitution of a worse hazard for the radiation avoided. Additionally, there should not be attempted the reduction of

small risks even further at the cost of large sums of money that spent otherwise, would clearly produce greater benefit."

The AEC position on the "as low as practicable" guidelines results from a substantial overestimation of the likely public exposures and underestimation of the cost of minimizing these exposures, producing a totally unrealistic cost-effectiveness index. When this is coupled with the total neglect of the in-plant exposure cost that may accrue, there exists a real and substantial basis for questioning whether the AEC has not, by this proposed action, generated more risk to the public of the United States by over-reacting to what has been in the past and will undoubtedly continue to be in the future an insignificant threat to the health of the public. It is my sincere hope that other nations will not blindly follow these actions of the U.S. Atomic Energy Commission without a very careful consideration of the implications of such a move on the total exposure budget of their populations. Certainly the blind appeasement of a small but loud segment of the public has not, in my view, contributed materially to the overall radiological welfare of the United States.

Thank you.