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RADIATION PROTECTION REGULATION: AN OPPORTUNITY FOR COOPERATIVE FEDERALISM

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INTRODUCTION

Part of the price that society must pay for nuclear progress is the subjection of some of its members to radiological hazards that are created in the process of putting nuclear fission, radioactive isotopes and radiation producing machines to work. Some of these hazards are of an industrial health nature; some involve public health. Both the federal government and many state governments have already taken regulatory action aimed at holding radiation hazards to tolerable levels.

The purpose of this article is to explore the question of how governmental responsibility for regulation of radiation hazards associated with atomic energy activities may best be allocated between the federal government and the states. While division of such responsibility is theoretically not essential—it being legally conceivable that the federal government could shoulder the entire responsibility alone or could leave it entirely to the states—various factors which will be mentioned below appear to make some sort of division of responsibility a practical necessity. To explore this question of division of responsibility, we shall first review the nature of radiation and the hazards of radiation exposure, to protect against which governmental regulation is deemed to be necessary. We shall next review the present status of state and federal radiation protection regulatory patterns. Finally, we shall set forth our conclusions as to the proper role of federal and state governments at this time. It is our hope, in writing this article, that our observations will be found worthy of consideration by legislators and administrators, both state and federal, who are presently at work establishing public policy for the protection of the citizens of their jurisdictions from excessive radiation exposure.

The process of establishing effective governmental regulation in any field (using the term "regulation" generically to include both statutes and administrative rules) involves the following four general steps:

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(a) Identifying the problem: determining the need for and general objective of governmental regulation;
(b) Determining the standards which define acceptable and unacceptable activity;
(c) Formulating regulations which will achieve the desired standards in an administratively practicable manner; and
(d) Devising procedures to enforce compliance.

While the foregoing steps are, of course, all interrelated, it is useful at times to address one's attention to them one at a time.

In the field of radiation protection, the presence of widespread federal regulation plus the increasing attention to the subject occurring at the state level[1] demonstrate that in many quarters the need for governmental regulation of some sort is already felt. Step (a) above has already been taken.

Step (b) is not primarily a legal matter; rather, it is largely within the field of medical science and health physics. It involves a variety of factors which are not part of the ordinary lawyer's or lawmaker's stock in trade. Nevertheless, because regulating radiation exposure involves blending nuclear medicine and legal procedure, it is essential that persons acting in this field have at least a general understanding of the relevant factors in each discipline that come into play. Accordingly, for the purpose of this article in a legal journal, considerable attention will be given to step (b). Furthermore, in order for one realistically to entertain the question of how governmental responsibility for radiation protection ought to be divided between the federal government and the states, a general understanding of the basic criteria underlying present day radiation protection programs is essential.

Steps (c) and (d) will not here be considered in any detail, since our primary purpose to suggest how best to allocate the responsibility for radiation protection between the federal government and the states.

I. THE NATURE OF RADIATION AND THE HAZARDS OF RADIATION EXPOSURE

A. *Ionizing Radiation and Its Measurement*

Ionizing radiation is electromagnetic radiation or particulate radiation capable of producing "ionization" in its passage through air or other matter. Ionization is almost always caused by the removal of an outer shell electron from a neutral atom or molecule, leaving it with a positive charge. Ionization of human tissue is harmful. While radiation can damage tissue by various interaction processes, of which ionization is only one, ionization is the easiest to measure and is

1. See part III. C. *infra.*

usually assumed to be a constant fraction of total damage. Consequently, ionizing radiation is the principal subject of attention when one investigates regulation for radiation protection.

The principal types of ionizing radiation are:

a. X-rays (Roentgen Rays), which are electromagnetic radiation usually produced in a machine by bombarding a suitable target material with high speed electrons. They can range in voltage from a few volts up to millions of volts. X-rays are of varying penetrating power.
b. Gamma rays, which are the same as X-rays, except that they originate from the nucleus of an atom and have a discrete rather than continuous energy spectrum.
c. Alpha particles, which are helium nuclei traveling at high speed.
d. Beta particles, which are electrons or positrons ejected from a nucleus at high speed.
e. Neutrons. High speed neutrons cause ionization directly by impact upon nuclei of other atoms; thermal (slow) neutrons enter into nuclear reactions with other atoms, thereby indirectly causing the release of ionizing radiation.
f. Heavy-particle radiation, which refers to atomic nuclei of any mass traveling at high speed.

Radiation varies as to its intensity. *Intensity of radiation* refers to the rate of energy flow through a unit area perpendicular to the radiation beam per unit of time.[2] It may be expressed in terms of ergs per square centimeter per second.[3] *Quantity of radiation,* accordingly, refers to the total energy that has passed through the unit area perpendicular to the radiation beam.[4] It includes the factor of time and is not merely a rate, as in the case of radiation *intensity.* Quantity of radiation may be expressed in terms of ergs per square centimeter. A *dose* of ionizing radiation refers to a quantity of radiation.[5]

For the purpose of setting permissible radiation exposure levels there has been some difficulty in establishing a suitable unit of dose measurement. The "roentgen" has been customarily used to express a unit of quantity of X-radiation or gamma radiation. A roentgen, which is defined in terms of ionizing effect in air, is "the quantity

2. NATIONAL BUREAU OF STANDARDS HANDBOOK No. 59, PERMISSIBLE DOSE FROM EXTERNAL SOURCES OF IONIZING RADIATION 5 (1954), Recommendations of the National Committee on Radiation Protection (This booklet will hereafter be referred to as "NBS Handbook No. 59").
3. An "erg" is a unit of work. It is equal to one dyne of energy working through a distance of one centimeter. A "dyne" in turn, is a unit of force capable of making a mass of one gram accelerate at the rate of one centimeter per second.
4. NBS HANDBOOK No. 59, at 5.
5. *Ibid.*

of X- or gamma radiation such that the associated corpuscular emission per .001293 grams of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign."[6] While the roentgen has in the past been used to establish values for permissible doses, it is unsatisfactory for such purpose and has been largely discontinued. It is unsatisfactory first because it is in terms of the effect of radiation in air. What is important in determining radiobiological effects of radiation is *absorbed* tissue dose.

An absorbed dose of ionizing radiation is the amount of energy imparted to matter by ionizing particles per unit of mass of irradiated material at the place of interest.[7] Because radiation has a scattering effect, an absorbed tissue dose will differ from an absorbed air dose from the same quantity of the same type of radiation. For instance, an exposure of a patient to a known radiation dose of twenty roentgens per minute for ten minutes, which would be measured in air as 200 roentgens, might create an absorbed surface tissue dose from 220 to 300 roentgens.[8] Furthermore, X-rays can be of widely varying voltage ranges, with varying degrees of penetrating power. The absorbed tissue dose of a one roentgen of low voltage ("soft") X-rays is not the same as the absorbed tissue dose of a one roentgen of high voltage ("hard") X-rays. In addition, the roentgen was used only for X- and gamma rays. A different unit of measurement, the *rep* (roentgen-equivalent-physical) was developed for specification of a roughly equivalent dose of radiation other than X-rays and gamma rays. The rep is a unit of *absorbed dose* (therefore dissimilar to the roentgen, which is not a unit of absorbed dose, even in the air) with a magnitude of 93 ergs per gram.[9]

Upon publication of *NBS Handbook No. 59* in 1954, the National Committee on Radiation Protection adopted the *rad* as the unit of absorbed dose for all types of radiation.[10] A rad is 100 ergs per gram.[11] However, even the rad fails as an effective common denominator unit for specification of permissible radiation exposure. The biological effect of 100 rads of one type of radiation is not necessarily the same as the biological effect of 100 rads of another type of radiation. Moreover, even the same type and quantity of ionizing radiation affects different types of cells differently. While there is no such thing as exact equivalence of biological damage produced by X-rays, neutrons, and alpha and beta rays or particles, the *rem* is the name of the unit employed for such purpose. It is defined as "the quantity of any ionizing

6. *Id.* at 6.
7. *Ibid.*
8. *Id.* at 6-7.
9. *Id.* at 6.
10. *Ibid.*
11. *Ibid.*

radiation such that the energy imparted to a biological system (cell, tissue, organ, or organism) per gram of living matter by the ionizing particles present in the region of interest, has the same biological effectiveness as an absorbed dose of 1 rad of X-radiation with average specific ionization of 100 ion pairs per micron of water in the same region."[12] Using a conversion factor known as *RBE* (relative biological effectiveness), which is determined empirically for the several types of radiation, one can determine the number of rems that any given number of rads of any type of radiation will produce. Most federal and state radiation protection regulations couch maximum permissible doses in terms of rems.

B. *Sources of Radiation*

Sources of radiation are manifold. First, there is "background radiation," which is the radiation from cosmic rays from outer space and from radioactive materials in place in nature. Background radiation is a normal part of the environment in which man has always lived. It is therefore generally considered not to be harmful.

Next, there is radiation from concentrations of naturally occurring radioactive materials—primarily radium, thorium, and uranium. While not of significance in their disposition in nature, these materials can pose a health hazard when handled in the process of being mined, refined or concentrated.

Thirdly, radiation can be artificially created by machines: X-ray machines, fluoroscopes, and various types of particle accelerators (Van de Graaff accelerators, cyclotrons, betatrons, synchrotrons, cosmotrons, etc.). These machines are valuable for a number of different applications. Their operation can also cause some risk to persons in their vicinity.

In the fourth place, radiation can be created in the process of nuclear fission. Nuclear fission creates basically three products: heat, radiation, and radioactive isotopes or "fission fragments." In nuclear weapons the fission process is not contained, but rather is designed to achieve destructiveness of varying amounts according to the mission. Nuclear reactors, on the other hand, are designed to provide continuing control over the fission process and have shielding to protect persons in the vicinity from the hazard of direct radiation exposure; they may also provide positive containment, if necessary, to protect against any escape of radioactive fission fragments. Reactors can be designed to "maximize" either the heat produced, the direct radiation produced, or the radioactive isotopes produced.

Fifthly, radiation can be produced by nuclear fusion. While fission occurs upon splitting of certain atoms which are very heavy in the

12. *Id.* at 31.

atomic tables, fusion occurs when certain very light elements join together to form new atoms. In both processes, large amounts of energy can be released. In both processes there is considerable release of direct radiation. However, in the fusion process the problem of radioactive fission fragments is not present.

Finally, radiation is emitted by materials made radioactive artificially. Many materials which are not radioactive in a natural state can be made so by bombardment in a particle accelerator or by being exposed to neutron radiation from a nuclear fission process. Fission fragments created during the course of nuclear fission may likewise be considered artificially created radioactive isotopes.

C. *Effects of Radiation Upon Man*

It is generally understood that "small" doses of radiation, such as those which nearly everyone has received in a doctor's or dentist's office, involve no hazard to one's well being, while "large" doses of radiation, such as those from nuclear bombs, can cause serious injury or death. Something more definite than this type of general understanding is needed, however, when one confronts the question what to do about regulating exposure.

The following table provides, as a start, a general indication of the effects upon man of various "acute" doses of radiation, *i.e.*, doses received within a 24-hour period:

PROBABLE EARLY EFFECTS OF ACUTE RADIATION DOSES OVER WHOLE BODY TO MAN[13]

Acute Doses (Rems)	*Probable Effects*
0-25	No obvious injury
25-50	Possible blood changes, but no serious injury
50-100	Blood-cell changes, some injury, no disability
100-200	Injury, possible disability
200-400	Injury and disability certain, death possible
400	Fatal to 50 per cent
600 or more	Possibly fatal to 100 per cent

The information in the above table is of statistical derivation. Actually, there is a variation in the effects of radiation upon different persons. The acute dose that will kill fifty per cent of persons exposed is about 400 rem. Twice this dose will kill all persons; half such dose

13. U.S. DEP'T HEALTH, EDUC. AND WELFARE, KINSMAN, RADIOLOGICAL HEALTH HANDBOOK 183 (1957) (hereafter referred to as "USPHS Handbook").

will prove fatal to a few. It will thus be noted that there is approximately a factor of four in the variation of effects of radiation in the lethal dose range upon different individuals. A similar spread exists in the lower dose ranges where the effects are less severe. It probably also exists in the still lower "permissible dose" range, where the effects of radiation are generally not perceptible. This phenomenon is not unique to radiation caused injury, but is comparable to the variability of effect of any given physiological stimulus on biological organisms.[14]

A special phenomenon of radiation injury is the time lapse between the manifestation of injury and the exposure to ionizing radiation causing the injury. Where the radiation dose is relatively high, the delay in appearance of injury is relatively short; where the dose is low, the latent period may be very long, as much as twenty five years.[15] Unfortunately, it is concerning the long delayed effects of small doses of radiation about which scientific knowledge is still somewhat scanty today. The following table is a summary showing some of the symptoms, including the latent period, following relatively severe acute doses of radiation:

SUMMARY OF EFFECTS RESULTING FROM WHOLE BODY EXPOSURE TO RADIATION TO MAN[16]

	Mild Dose
0-25 rem	No detectable clinical effects Probably no delayed effects
50 rem	Slight transient reductions in lymphocytes and neutrophils No other clinically detectable effects
	Moderate Dose
100 rem	Nausea and fatigue with possible vomiting above 125 Reduction in lymphocytes and neutrophils with delayed recovery Delayed effects may shorten life expectancy as much as one per cent
200 rem	Nausea and vomiting within 24 hours Latent period about one week, perhaps longer Following latent period, epilation, loss of appetite, and general malaise Sore throat, pallor, petechiae, diarrhea Moderate emaciation

14. NBS HANDBOOK No. 59, at 8-9.
15. *Id.* at 9.
16. USPHS HANDBOOK at 183.

Possible death in 2 to 6 weeks in a small portion of individuals
Recovery likely unless complicated by poor previous health, superimposed injuries or infections

Median Lethal Dose

400 rem
Nausea and vomiting in 1 to 2 hours
Latent period, perhaps as long as one week
Beginning epilation, loss of appetite, and general malaise accompanied by fever and severe inflammation of mouth and throat the third week
Pallor, petechiae, diarrhea, nosebleeds, rapid emaciation about the fourth week
Some deaths in 2 to 6 weeks. Possible eventual death to 50% of the exposed individuals

Lethal Dose

600 rem
Nausea and vomiting in 1 to 2 hours
Short latent period following initial nausea
Diarrhea, vomiting, inflammation of mouth and throat toward end of first week
Fever, rapid emaciation and death as early as the second week with a possible eventual death to 100% of exposed individuals.

While successive radiation doses have a cumulative effect, it is not a matter of simple addition to determine the total effective dose. Living organisms have a recuperative power which comes into play to provide natural recovery for radiation injury in a manner comparable to their recuperative power for other types of injury.[17] Such power provides a mitigating effect in cases of radiation exposure. The following table illustrates the difference between total accumulated dose and effective accumulated dose for various dose rates:

ESTIMATE OF EFFECTIVE DOSE FROM VARIOUS DOSE RATES TO MAN[18]

Days	Accumulated Dose (Rem)	Effective Accumulated Dose (Rem)
	50 Rem per Day Exposure	
1	50	50
3	150	135
5	250	204
10	500	330
15	750	395

17. NBS HANDBOOK No. 59, at 9-12.
18. USPHS HANDBOOK at 184.

	100 Rem per Day Exposure	
1	100	100
3	300	271
5	500	409
10	1000	663
	200 Rem per Day Exposure	
1	200	200
3	600	542
5	1000	819
10	2000	1326

Injury to man is not the result of ionizing radiation penetrating and injuring one particular critical spot in one's anatomy. It can cause injury to any part of one's system. We have previously noted that different types of radiation produce different degrees of injury to human tissue. The same type of radiation may cause different degrees of injury to different cell types. Other variations, such as in the duration of exposure, can not only cause changes in both the effect of radiation exposure, but also the relative effectiveness upon different types of cells. The following tables illustrate these points:

ILLUSTRATION OF DIFFERENTIAL VARIATIONS WITH RESPECT TO SPECIFIC IONIZATION[19]

Lethal Dose in Rads

	X-Rays	*Fast Neutrons*	*Dose Ratio X-Rays to Fast Neutrons*
Cell Type A	1,000	200	5
Cell Type B	2,000	500	4
Dose Ratio B/A	2	2.5	—

ILLUSTRATION OF DIFFERENTIAL VARIATIONS WITH RESPECT TO TIME FACTOR[20]

Lethal X-Ray Dose in Rads

	Short Exposure	*Long Exposure*	*Dose Ratio— Long to Short*
Cell Type P	1,000	1,500	1.5
Cell Type Q	2,000	2,500	1.25
Dose Ratio, Q/P	2	1.67	——

In the words of the National Committee on Radiation Protection (NCRP):

19. NBS HANDBOOK No. 59, at 15.
20. *Ibid.*

> In dealing with the biological effects of ionizing radiation in general, whether we think in terms of radiosensitivity or biological effectiveness, we are inexorably 'plagued' by 'differences in differences.' The typical problem involves two distinct biological entities and two radiations of significantly different specific ionizations. . . . [Illustrated by the first table above.]
>
> Differential variations may occur with only one type of radiation when another parameter is different. [Illustrated by the second table above, time being the parameter.] There are of course many other types of differential variations; for instance, with respect to age, oxygen tension, temperature, etc.[21]

Given a known radiation exposure to a limited portion of the body and complete knowledge about the particular organism irradiated, it is theoretically possible to predict the injury to a particular organ, within the limits of biological variability, by taking into account the ionizing properties of the radiation, its penetrating power, the scattering effect upon its passage through tissue, the attenuation caused by its traversing matter, and the radiosensitivity of the organ in question. The case presented by exposure of the entire body to ionizing radiation is much more complicated. While all organs are irradiated, some receive relatively larger doses than others, due to differences in size or location. Furthermore, injury to any particular organ may be caused not only directly by the radiation but also indirectly by the failure of some other organ to function properly. In the words of the NCRP:

> The situation concerning exposure of the entire body to radiation may be summarized as follows: The distribution of radiation within the body determines the doses received by the different organs. The effects produced in each depend largely on the dose and the radiosensitivity of the organ. The combination and interaction of all these effects in different organs of the body will modify the over-all effects. All other conditions being the same, differences in over-all effects, in degree and/or in kind, can be expected:
>
> (1) When the distribution of radiation within the body is different, because the relative doses received by the organs will be different;
>
> (2) When the total dose is different, because all organs are affected more by larger doses and some organs that are unharmed by small doses will be injured by larger doses;
>
> (3) When the time of administration of the total dose is different, because of differential variations due to changes in the relative radiosensitivities of the organs (largely due to inherent differences in recovery rates for different organs);
>
> (4) When the instantaneous dosage rate or the dose fractionation with respect to time is different, because of possible differential variations due to changes in relative radiosensitivity;
>
> (5) When the specific ionization is different (two different kinds of radiation), because of differential variations due to difference in RBE;

21. *Id.* at 14-15.

(6) When the tissue depth-distribution of the specific ionization is different, because the RBE at different depths will be different;
(7) When, in general, any factor that introduces differential variations is different.[22]

Ordinarily, however, nobody will have complete knowledge about the physiological characteristics of any particular organ, not to speak of an entire human body. There has therefore been developed the concept of the "standard" man, an idea no doubt capable of raising the eyebrows of the legal fraternity, accustomed as it is to dealing with a different hypothetical being, the "reasonable" man. The standard man concept is simply a tabulation which ascribes specific quantitative values to the various physiological characteristics of an average human being for the purpose of making analytical computations of the effects of radiation on a person. For instance, for every organ in an adult human body it provides figures for its mass in grams, its per cent of total body, and its effective radius. The standard man concept also includes figures for the chemical composition of the average individual and other data of relevance in calculating radiation injury.[23]

While our attention thus far has been directed toward the effects upon human beings of ionizing radiation from sources external to the body, one must not overlook the hazard presented by sources of radiation internal to a body. A radioisotope which finds its way inside a human body will cause more harm than a like source outside.[24] The reason for this is that a radiation source inside the body will continuously irradiate parts of the body until it is eliminated or decays to a level of activity that is not significant. Furthermore, low energy radiation (which, if from an external source, would be stopped by skin and tissue before reaching any critical organs) presents the possibility of injury by coming in direct contact with a critical organ internally.

Radioisotopes can enter the body by inhalation, ingestion, or through pores or breaks in the skin. How the radiation source enters the body will have a bearing on the way it will be absorbed into the system, the length of time it will remain, and the particular organs it may affect.[25] All of these factors are material in ascertaining the hazard presented. Other factors of importance are the chemical form of the radioisotope and its physical state at the time of entry into the body.[26] And, of course, the quantity of radioactive material enter-

22. *Id.* at 16-17.
23. USPHS HANDBOOK at 193-96.
24. NATIONAL BUREAU OF STANDARDS HANDBOOK No. 52, MAXIMUM PERMISSIBLE AMOUNTS OF RADIOISOTOPES IN THE HUMAN BODY AND MAXIMUM PERMISSIBLE CONCENTRATIONS IN AIR AND WATER 3 (1953) (This booklet will hereafter be referred to as "NBS Handbook No. 52").
25. NBS HANDBOOK No. 52, at 6.
26. *Ibid.*

tained in the system is of prime importance. Elimination of sources of radiation inside the body is accomplished through exhalation, urination, defecation, perspiration, and possibly through physical removal of the tissue containing the radioisotope in question, by accident, surgery or natural processes.

Once a radioactive material has entered the system, the extent of damage that can be caused by it depends upon many factors in addition to those mentioned above: the amount that is initially absorbed (in, say, the gastrointestinal tract or the respiratory tract); the per cent of the initially absorbed amount which goes into the bloodstream; whether that which goes into the bloodstream becomes eliminated or is deposited in one or more particular body organs; the radiosensitivity of the portions of the body where the radioactive material is deposited; whether the material is deposited more or less evenly throughout the body, or instead is concentrated in one particular organ; the size of the affected organ relative to the quantity of radioactive material present; the importance of the affected organ to the proper functioning of the body as a whole; the rate of physiological elimination of the radioactive material once deposited in a critical organ, *i.e.*, its biological half-life; the length of time the material remains radioactive, *i.e.*, its radioactive half-life; and finally, the type of radiation emitted by the radiation source.[27]

"Differences within differences" occur in this situation too. The hazard from the same quantity of radioactive material absorbed in the same manner will vary with the individual involved: children will be affected differently from grown persons; pregnant women will be affected differently from women who are not pregnant; and there is always the factor of four in the biological variability among apparently similar individuals.[28]

There is some evidence that radiation exposure in sufficient doses tends to shorten lifespan.[29] This evidence is, apparently, based on controlled experiments with mice and rats. Because of the biological variability that must be taken into account in such experiments, the effects of small doses cannot be evaluated experimentally, but are derived by extrapolation of high dose data. Furthermore, since there is such a wide difference in biological organism between human beings and mice or rats, the only sound conclusion relative to man is that radiation exposure in sufficient doses is likely to shorten lifespan. Quantitative data in this regard is not yet available.

There is even more evidence that ionizing radiation can cause changes in genes and chromosomes in germ cells.[30] Again the evidence

27. *Id.* at 6-10.
28. *Id.* at 8-9.
29. NBS HANDBOOK No. 59, at 19-20.
30. *Id.* at 17-19.

with respect to genetic mutations is based upon experiments with animals. In this area, not only does biological variability cloud the issue, but one must reckon with the fact that genetic mutations occur "spontaneously," that is, for our purposes, from causes unrelated to exposure to radiation other than background. Cause and effect cannot be nicely identified and isolated. However, it is apparently established that the frequency of occurrence of genetic mutations is directly related to the magnitude of the radiation dose, regardless of duration of exposure, and that it is observable at relatively low radiation doses.[31] In any event, the deleterious (or, in rare cases, beneficial) effects of such radiation-induced genetic mutation will not become manifest in the lifetime of the person irradiated, but only in subsequent generations.

II. Present Concepts of Permissible Exposure to Ionizing Radiation

A. *Radiation Exposure as a Necessary, Reasonable Risk*

As with the development of steam power in the ninteenth century and the internal combustion engine in the early part of this century, the present-day development of atomic energy involves creation of new and socially desirable activities while at the same time creating new hazards to the health and safety of the populace. We are not dealing with an activity so hazardous or so socially insignificant that the prudent thing to do is to prohibit it altogether. Nor are we dealing with a socially desirable activity with hazards so insignificant that no special action need be taken to curb the harm that may be caused by it. Our field is one in which the benefits to be achieved through the use of atomic energy and ionizing radiation must be carefully balanced against the attendant hazards. We have, in the previous section, elaborated in some detail upon the hazards associated with ionizing radiation. It may therefore be appropriate to mention, quite briefly, some of the many advantages gained through its use: alleviation of untold suffering and death through diagnostic and therapeutic use of X-rays; savings of millions of dollars annually in industry through use of radioisotopes; substantial augmentation of the world's available power supplies through use of nuclear power reactors; creation of new capabilities for sustained land, sea, air and space transportation by use of nuclear propulsion reactors; and discovery of more information about the fundamental nature of the universe in which we live.

The basic problem of radiation protection is, therefore, to ascertain how much radiation exposure may be permitted for individuals or groups while pursuing the desired benefits, by the light of the best

31. *Id.* at 17.

current understanding of both the ends sought and the hazards involved.[32] A separate problem (and one which we shall not consider in this article) is to determine what special measures, if any, are required to provide appropriate compensation to those who are injured by such exposure.

B. *Basic Criteria for Radiation Protection*

In this country the National Committee on Radiation Protection (NCRP)[33] has established the basic criteria for permissible exposure to radiation. One starts from the proposition that there is, strictly speaking, no radiation dose level so low that one can say categorically it will not cause harm.[34] The NCRP defines "permissible dose" as:

> the dose of ionizing radiation that, in the light of present knowledge, is not expected to cause appreciable body injury to a person at any time during his lifetime.[35]

It goes on to define a "permissible weekly dose" as:

> a dose of ionizing radiation accumulated in one week of such magnitude that, in the light of present knowledge, exposure at this weekly rate for an infinite period of time, is not expected to cause appreciable bodily injury to a person at any time during his lifetime.[36]

By "appreciable bodily injury" is meant:

> any bodily injury or effect that the average person would regard as being objectionable and/or competent medical authorities would regard as being deleterious to the health and well-being of the individual.[37]

In *NBS Handbook No. 59*,[38] the NCRP provides a series of rules setting specific values for permissible weekly doses of various types of ionizing radiation, with special reference to:

a. Specific organs or parts of the body exposed
b. Types of radiation involved
c. Age of the person exposed, in relevant cases
d. Non-occupational *vs.* occupational exposure
e. Accidental or emergency exposure to larger than weekly permissible doses

We shall not here consider these rules in detail, except to note the general basic permissible weekly tissue dose for exposure of adults

32. See Taylor, *Radiation Exposure as a Reasonable Calculated Risk*, 1 HEALTH PHYSICS 62 (1958), for an exposition of this same point of view—and in a lawyerlike manner—by Dr. Lauriston S. Taylor, Chairman of the National Committee on Radiation Protection.

33. See part III *infra*, for a discussion of the organization and activities of the National Committee on Radiation Protection.

34. NBS HANDBOOK No. 49, at 20-21, 74.

35. *Id.* at 27.

36. *Ibid.*

37. *Ibid.*

38. *Id.* at 61-73.

under forty-five years of age to ionizing radiation from external sources for an indefinite period of years, which is as follows:[39]

Skin	600 mrem (millirem)
Bloodforming Organs	300 mrem
Gonads	300 mrem
Lens of the Eye	300 mrem

(Note: a millirem is 1/1000 of a rem)
Other organs and tissues of the body are between 600 and 300 millirems depending upon depth of the region in interest from the surface of the body, according to a special table.

In *NBS Handbook No. 52* the NCRP provides a table of maximum concentrations of radioisotopes permissible in the human body.[40] These values are presumably consistent with those in *Handbook No. 59* and are based upon consideration of all of the factors noted above in the discussion of internal radiation exposure.

Thus far we have been talking primarily about occupational exposure. Detailed information about radiation exposure and ability to control it depends upon personnel control in the areas where such exposure is capable of taking place. The NCRP also recognizes the possibility of non-occupational exposure. Non-occupational exposure to direct radiation outside a controlled area will not ordinarily exceed that inside the area. The NCRP therefore directs its attention, in the case of non-occupational exposure, primarily toward protection of minors (persons under 18), whose radiosensitivity is greater than that of adults. It recommends that activities be conducted in such a manner that no minor receives a dose in excess of one-tenth of the values specified in *NBS Handbook No. 59*.[41]

Maximum permissible concentrations of radioisotopes that may be released to the environment in air or water beyond the control of the user are specified in *NBS Handbook No. 52*.[42]

C. *Changing Standards of Permissible Exposure to Radiation*

It should be borne in mind that over the years there have been several changes in the thinking as to what constitutes acceptable radiation exposure. Each change to date has been in the direction of

39. *Id.* at 42-43, 61-62.
40. NBS HANDBOOK No. 52, at 14-16.
41. NBS HANDBOOK No. 59, at 57.
42. NBS HANDBOOK No. 52, at 11. A more recent listing of maximum permissible amounts of radioisotopes in the human body and the maximum permissible concentrations in air and water for continuous exposure appears in USPHS HANDBOOK at 187-91.

lower limits. Permissible occupational exposure doses have varied approximately as follows:[43]

		Rems/Year
Prior to 1934	Approx.	100
1934-1935 (200 mrem/day)		60
1935-1948 (100 mrem/day)		30
1948-1957 (300 mrem/wk)		15
1957-		5

This trend reflects a number of factors and should not be interpreted to mean that the scientists previously underestimated the hazards of radiation exposure by a factor of twelve or more. In the first place, prior to World War II, occupational exposure was, by and large, confined to radiologists and other professionals. This group was small in total number, and its members were generally aware of the desirability of keeping radiation exposure to a minimum. The average of 300 mrem per week or fifteen rems per year (fifty work-weeks per year) was established after World War II at a time when widespread uses of atomic energy were just beginning and the numbers of persons subject to exposure vastly increased. In addition, more information had then become available about the biological effects of radiation. Lastly, instrumentation capable of measuring and recording such lower dosages was then available. In short, lower levels were set not because it was unduly dangerous to be exposed at the higher levels but because "the best radiation dose is no dose" and because it was then feasible to prescribe lower limits.[44]

In 1954, when *NBS Handbook No. 59* was first published, the NCRP did not believe that genetic damage was a limiting factor in setting permissible levels for occupational exposure. Its reason was that the primary concern of the geneticists is not the dose per individual, but rather the total dose to the population:

> The amount of radiation received by the gonads of one individual, up to the time of conception of the last child in his family, can be very large without noticeably damaging the population as a whole—provided that only a very small fraction of the whole population is exposed to this extent.[45]

Concern for injury to the individual, rather than genetic injury to the entire population was the basis of the rules in *Handbook No. 59.* Because of increased concern for genetic injury arising from more widespread use of radioactive materials, rapid advances in the development of nuclear power, and rising concern over fall-out, the NCRP

43. Taylor, *Radiation Exposure as a Reasonable Calculated Risk,* 1 HEALTH PHYSICS 62 (1958).
44. See Taylor, *op. cit supra* at 64-65.
45. NBS HANDBOOK No. 49, at 18.

in January of 1957 issued a preliminary statement revising its previous maximum permissible exposures to ionizing radiation to, in general, one-third of previously established levels. More precisely, in the words of the Chairman of the NCRP, it provided:

> *Accumulated Dose.* The maximum permissible accumulated dose, in rems, at any age, is equal to 5 times the number of years beyond age 18, provided no annual increment exceeds 15 rems. Thus the accumulated MPD = 5(N-18) rems where N is the age and greater than 18. This applies to all critical organs except the skin, for which the value is double.[46]

Undoubtedly the NCRP took into account, when making its new recommendation, the facts that most radiation users maintained a sufficient margin of safety under the old permissible levels to allow them to meet the new standard, and that advances in the field of nuclear instrumentation made compliance with the new level feasible.

This progressive lowering of maximum permissible dose levels is really a tribute to the nuclear industry: it represents major progress toward the ultimate in radiation protection, namely, no occupational exposure in excess of background (or no occupational exposure at all).

Both NBS *Handbooks* numbers 52 and 59 are made out of date by this new change in permissible level, as are all other NBS *Handbooks* relying upon the old permissible levels, and, as we shall see in the following section, all state and federal regulations based upon the old levels. The National Committee on Radiation Protection is currently in the process of rewriting its *Handbooks* in a manner consistent with its new philosophy.

D. *Radiation Detection and Measurement Instrumentation*

Atomic age wags have been heard to say that one doesn't have a health physics problem until he employs a health physicist. The grain of truth in the statement is that unless an organization has someone available to it who understands radiation hazards and who has sufficient nuclear instrumentation at his command to detect and measure radiation doses, persons may be exposed to ionizing radiation without one ever knowing it. Because radiation cannot be detected by human senses, special instruments must be employed to determine how much of a dose, if any, a person is receiving. In performing his duty of protecting persons from all unnecessary radiation exposure, and keeping necessary exposures within permissible limits, the health physicist relies primarily upon detailed knowledge of the radiation sources and their intended use. On the basis of such knowledge, he can work out, or at least approve, procedures which insure maximum safety under the circumstances. Secondarily, he relies upon

46. Taylor, *op. cit. supra* note 43, at 67.

personnel and area radiation monitoring instruments which reveal how much of a dose an individual has received and what sort of concentrations of radioactive material (or levels of direct radiation) are building up in the air or elsewhere at points of interest. Various types of film badges and dosimeters are available for this purpose. Internal concentrations of radioactive materials are determined by use of a "human counter" or by laboratory analysis of urine and fecal samples. For the purposes of our present discussion it is sufficient to note that any standard of radiation protection must be realistic with respect to the state of the art of nuclear instrumentation at the time. While the new lower levels will require certain new health physics procedures and possibly new instrumentation, there is apparently no insurmountable problem in this regard.

E. *The Over-All Radiation Protection Problem*

The new NCRP standards are consistent with the recommendations made in 1956 by the International Commission on Radiation Protection:

> (1) for the population as a whole, the average per capita dose should not exceed 10 rems, from conception up to age 30 (and by inference one-third of this amount per decade thereafter); (2) for radiation workers, the individual occupational dose should not exceed 50 rems up to age 30 (and by inference again this same amount per decade thereafter).[47]

The following table was prepared by the chairman of the National Committee on Radiation Protection to indicate the relative importance of different types of radiation exposure, based on estimates of conditions in the United States today:

RADIATION DOSE RECEIVED UP TO AGE 30[48]

Type of Radiation	*Dose in Man-rems Per Million of Population*
Natural Radiation (background)	4,000,000
Medical Irradiation	5,000,000
Occupational Exposure	150,000
Radiation in Plant Environs	
At 1/10 of New MPD	(150,000)
At 1/10 of Old MPD	450,000
Fall-out	200,000
Total	9,800,000
Maximum Permissible Dose	14,000,000
Balance	4,200,000

47. Taylor, *op. cit. supra* note 43, at 66.
48. Taylor, *op. cit. supra* note 43, at 70.

The maximum permissible dose of fourteen million man-rems is derived by taking the average per capita dose of ten rems, multiplying it by a million and adding the four million man-rems of background radiation. Medical irradiation is estimated. Occupational exposure is calculated on the basis of five rems per year for one-fourth of one per cent of the population over a period of twelve years (age 18-30). Non-occupational exposure (radiation in plant environs) is estimated on the basis of irradiating one per cent of the population over a period of thirty years. At the old permissible levels, this comes to 450,000 man-rems; if the new levels make this permissible dose one-tenth of the new permissible occupational exposure dose, it will be 150,000 man-rems. Fall-out is placed at double the current rate.

This table helps to put in proper perspective the relative importance of radiation exposure from regulated sources (occupational and plant environs exposure) and background, medical, and fall-out radiation exposure. The purpose of drawing these comparisons it to underscore the fact that the hazard to our population at large from radiation exposure from peace time applications of atomic energy is *not* a matter of alarming proportion today. It would be a mistake to take precipitous action to reduce occupational and plant environs radiation exposure levels by, say, fifty per cent in the hope of reducing over-all population exposure by half. Peacetime uses of atomic energy only contribute approximately five per cent to the total radiation exposure of the population. Elimination of all industrially caused radiation exposure could not, therefore, reduce the total dose to the population more than about five per cent. Conversely, however, one should not be complacent about the hazard. Permissible exposure levels must be set and enforced in such manner that there is no appreciable risk of harm to atomic energy workers or members of the public living in the vicinity of nuclear facilities.

F. *Special Cases—Medical Irradiation and Fall-Out*

Two special situations deserve brief mention. The first of these is the intentional irradiation of persons for medical reasons, diagnostic or therapeutic. The object of our attention is the patient, not the doctor or X-ray machine operator who may also be exposed. As to such non-patients, the permissible levels for occupational exposure are applicable. Use of X-ray machines and fluoroscopes by doctors and dentists is widespread. When properly handled, each such intentional medical exposure should be preceded by a balancing of the benefits to be gained by such exposure against the risk of harm that may be caused at the same time. It then rests in the doctor's professional judgment whether or not to carry out the irradiation. Careful use of shields for X-ray machines and careful placement of radioactive

sources in a patient's body can do much to minimize the potential hazard. The actual dose given to the patient is, of course, not considered to be within the scope of the rules dealing with permissible radiation exposure levels, nor is the fact that one receives medical irradiation a basis for reducing the level of occupational exposure otherwise permissible.

The second special situation is fall-out, which is the deposition of radioactive debris from nuclear weapons testing. Like background radiation, fall-out affects the entire population more or less uniformly. The total population dose from fall-out is slight in comparison to background radiation and presents no health or safety problems at the present time. However, it does represent a deliberate exposure of the public to radiation in excess of background. It is presently accepted as a necessary consequence of military preparedness.

III. A REVIEW OF RADIATION PROTECTION REGULATION IN THE UNITED STATES

A. *Voluntary Self-Control*

In 1929 under the sponsorship of the National Bureau of Standards there was established an Advisory Committee on X-ray and Radium Protection, having a membership representing professional, commercial and governmental groups concerned with safety in the use of radioactive materials (then, primarily radium) and X-ray machines. Prior to World War II this Committee issued the following publications:

X-ray Protection, NBS Handbook 15 (1931)
(Superseded by Handbook 20 in 1936)
Radium Protection for Amounts Up to 300 mg, NBS Handbook 18 (1934)
(Superseded by Handbook 23 in 1938)
X-ray Protection, NBS Handbook 20 (1936)
(Superseded by Handbook 41 in 1949)
Radium Protection, NBS Handbook 23
(Superseded by Handbook 54 in 1954)

As can be seen from the titles of the handbooks, during this period the attention of the Committee was addressed primarily, if not exclusively, to the safety aspects of ionizing radiation from the use of X-ray machines and radium. The handbooks were written as guides for persons who might be exposed to radiation from such sources. They were not regulations in any sense of the word; the Committee, as a voluntary association, had no regulatory authority over anyone.

After World War II it was apparent that the matter of radiation protection had acquired a new dimension. In 1946 the Advisory Com-

mittee was substantially enlarged, the number of participating organizations increased, and its name changed to the National Committee on Radiation Protection. It now functions through a central committee and some 18 subcommittees. In the main it continues to provide the same service as before the war, but on a much broader front. Its postwar publications include:

Medical X-ray Protection up to Two Million Volts
NBS Handbook 41 (1949)
(Superseded by Handbook 60 in 1955)

Safe Handling of Radioactive Isotopes
NBS Handbook 42 (1949)

Control and Removal of Radioactive Contamination in Laboratories, NBS Handbook 48 (1941)

Recommendations for Waste Disposal of Phosphorous-32 And Iodine-131 for Medical Users, NBS Handbook 49 (1951)

Radiological Monitoring Methods and Instruments, NBS Handbook 51 (1952)

Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water, NBS Handbook 52 (1953)

Recommendations for the Disposal of Carbon-14 Wastes, NBS Handbook 53 (1954)

Protection Against Radiations from Radium, Cobalt-60, and Cesium-137, NBS Handbook 54 (1954)

Protection Against Betatron-Synchrotron Radiations Up to 100 Million Electron Volts, NBS Handbook 55 (1954)

Safe Handling of Cadavers Containing Radioactive Isotopes, NBS Handbook 56 (1953)
(Superseded by Handbook 65 in 1958)

Radioactive Waste Disposal in the Ocean, NBS Handbook 58 (1954)

Permissible Dose from External Sources of Ionizing Radiation, NBS Handbook 59 (1954)

X-ray Protection, NBS Handbook 60 (1955)

Regulation of Radiation Exposure by Legislative Means, NBS Handbook 61 (1955)

Protection Against Neutron Radiation Up to 30 Million Electron Volts, NBS Handbook 63 (1957)

Design of Free-Air Ionization Chambers, NBS Handbook 64 (1957)

Safe Handling of Bodies Containing Radioactive Isotopes, NBS Handbook 65 (1958)

Safe Design and Use of Industrial Beta-ray Sources, NBS Handbook 66 (1958)

While the NCRP did not undertake to recommend (or oppose, for

that matter) that governmental bodies formalize its radiation safety standards and procedures into regulations, it nevertheless offered its assistance to any such body desiring to do so. By such procedure it endeavored to assure that such regulations would be technically sound and practically workable. NBS *Handbook No. 61,* Regulation of Radiation Exposure by Legislative Means, represented a special effort by the NCRP to provide specific guidelines to state governments in this respect. *Handbook 61* states the NCRP's philosophy on regulated radiation protection; a discussion of what ought to be regulated and what not regulated; alternative possible approaches; and finally a model state Radiation Hygiene Act and model administrative regulations consistent with its other standards as of 1955.

The American Standards Association (ASA) is the second voluntary organization of major significance that is active in the field of radiation protection. This organization is concerned with establishment of uniform industrial standards in many fields of endeavor to the end that progress shall not be impeded by unnecessary diversity. In December of 1955 at a general conference the ASA initiated a program to establish a Nuclear Standards Board within the general framework of the ASA to formulate and adopt standards in the nuclear field in a manner consistent with procedures customarily used to establish industrial standards in other fields.[49]

The Nuclear Standards Board has established a number of committees and sub-committees to carry out various assigned tasks as follows:

- N-1 Glossary of Terms in Nuclear Science and Technology
- N-2 General and Administrative Standards, with subdivision:
  - 2.1 Color codes and symbols
  - 2.2 Procedures for Industrial Exposure Records
  - 2.3 Qualifications of Nuclear Professionals
  - 2.4 Nuclear Terminology
  - 2.5 Model Atomic Energy Legislation
- N-3 Nuclear Instruments
- N-4 Electrical Requirements for Reactors &c.
- N-5 Chemical Engineering for the Nuclear Field, with subdivisions:
  - 5.1 Fuel Manufacture &c.
  - 5.2 Radioactive Waste Disposal
  - 5.3 Recovery of Irradiated Fuel
  - 5.4 Use and Handling of Radioisotopes and High Energy Radiation
  - 5.5 Packaging and Transportation of Radioactive Materials

49. See ATOMIC INDUSTRIAL FORUM, INC., UTILIZATION OF NUCLEAR STANDARDS BY STATE GOVERNMENTS, SUMMARY OF MEETING SPONSORED BY THE COMMITTEE ON STANDARDS (1957).

N-6 Reactor Safety Standards, with subdivisions:
- 6.1 Site Evaluation
- 6.2 Containment
- 6.3 Fluid Systems of the Reactor and Fuel Within the Reactor
- 6.4 Reactor Dynamics and Control Requirements
- 6.5 Instrumentation and Execution of Control Requirements
- 6.6 Operation, Operator Qualifications, Inspection and Maintenance and Records
- 6.7 Failure Probabilities and Maximum Credible Accidents
- 6.8 Fissionable Material Outside Reactors

N-7 Radiation Protection, with subdivisions:
- 7.1 Uranium Mines and Mills
- 7.2 Safety Standards in Uranium and Thorium Refineries
- 7.3 Isotopic Separations
- 7.4 Health Physics of Fuel Element Fabrication
- 7.5 Health Physics for Reactors[50]

From the foregoing, it will be noted that the Nuclear Standards Board of the ASA is directing its attention to a number of nuclear standardization matters, of which radiation protection is only a part. Most of the Board's committees and subcommittees, which are composed of representatives of interested industrial associations, professional societies and governmental groups, are actively at work. It is too early today to assess what the impact of their actions will be, but one may safely prophesy that there will be systematic adoption of standards acceptable to all of the participating groups and an ever broadening area of substantial agreement on standards in all of the above areas—including that of radiation protection. Note that one of the ASA's avowed purposes is to develop model laws, including radiation protection laws, for matters of concern to the nuclear industry.

B. *Radiation Protection Regulation by the Federal Government*

Affirmative action by the federal government to achieve radiation protection may, in general, be divided into three major categories: (1) regulations applicable to shipments of radioactive materials by agencies having jurisdiction over interstate and foreign transportation; (2) comprehensive control by contract administration over contractors of the Atomic Energy Commission and Department of Defense governing all aspects of radiological safety connected with government contract programs; and (3) comprehensive regulation over AEC licensees governing radiation exposure from operation of licensed facilities or from use of source, special nuclear and by-product materials.

The federal agencies first concerned about control of radiation were

50. ASA Status Report of Projects Under the Jurisdiction of the Nuclear Standards Board No. CN-34, April 21, 1958.

those having jurisdiction over interstate and foreign commerce, namely, the Interstate Commerce Commission, the Civil Aeronautics Board, the Post Office and the Coast Guard.[51] They are concerned about protecting radiosensitive materials, such as photographic film, which can be damaged by proximity to radiation, and transportation personnel, who may be injured by radiation exposure from such materials while in transit. The ICC Regulations provide rather detailed provisions regarding packaging, shielding, and labelling of radioactive materials; limitations on amounts that may be packed in any one container; types of containers to be used; information to be included on the bills of lading; procedures for loading, unloading and storing such shipments; provisions for handling broken or damaged containers, etc.[52] Civil Air Regulations govern the transportation of radioactive materials by air. They are in general patterned after the ICC Regulations, but with somewhat more stringent provisions due to the different operating circumstances of aircraft.[53] The Coast Guard Regnlations are likewise patterned in large measure after the ICC Regulations.[54] Postal Regulations specify much more stringent requirements, probably due to the greater amount of handling of mails by personnel.[55] We need not here elaborate upon the details of these regulations; they apply to interstate and foreign commerce and hence occupy a realm which is, in any event, normally and properly within the jurisdiction of the federal government.

Many private organizations perform work involving radiation hazards under contract for the AEC. The Commission requires these contractors to comply with the radiation exposure limits set forth in Chapter 0524 of the AEC Manual.[56] Since December 1957, the AEC has specified, in general, that the most recently established NCRP standards, mentioned above, be the applicable radiation exposure limits to be adhered to by its contractors.[57] The Department of Defense apparently does not have comparable provisions in its Armed Services Procurement Regulation applicable to all of the Armed Services. The Air Force, nevertheless, as a matter of policy requires its CPFF contractors who perform any part of the contract upon premises

51. The AEC has recently published a booklet entitled "Handbook of Federal Regulations Applying to Transportation of Radioactive Materials," May, 1958, which conveniently collects the key regulations of the several federal agencies with jurisdiction in the field of transportation.
52. 49 C.F.R. Parts 71-78 (1956).
53. 14 C.F.R. Part 49 (1956).
54. 46 C.F.R. Part 146 (1958).
55. 39 C.F.R. Part 35 (1955).
56. The AEC Manual is a loose leaf service maintained by the Commission for guidance of AEC and contractor personnel in all phases of Commission policy and operations. Although not generally available, copies of the Manual are located at all major AEC installations.
57. AEC Release No. 1231, December 10, 1957.

under the control of the government to comply with specified requirements to assure the safety of government and contractor personnel.[58] Although we do not know of any study which apportions percentages of radiation hazards between activities under government contracts and private activities, we suspect that the great preponderance of non-medical work involving use of radioactive materials and radiation arises under government contracts; consequently, the great preponderance of effective governmental control today is probably exercised by the AEC and the Department of Defense through administration of the contracts pursuant to which such activities are performed.

PERMISSIBLE WEEKLY DOSE

Conditions of Exposure		Dose in Critical Organs (mrem)			
Parts of Body	*Radiation*	*Skin, at Basal Layer of Epidermis*	*Blood Forming Organs*	*Gonads*	*Lens of Eye*
Whole body	Any radiation with half-value-layer greater than 1 mm of soft tissue.	*600	*300	*300	*300
Whole body	Any radiation with half-value-layer less than 1 mm of soft tissue.	1,500	300	300	—
Hands and forearms or feet and ankles or head and neck	Any radiation	**1,500	—	300	—

* For exposures of the whole body to X- or gamma rays up to 3 mev, this condition may be assumed to be met if the "air dose" does not exceed 300 mr, provided the dose to the gonads does not exceed 300 mrem. "Air dose" means that the dose is measured by an appropriate instrument in air in the region of highest dosage rate to be occupied by an individual, without the presence of the human body or other absorbing and scattering material.

** Exposure of these limited portions of the body under these conditions does not alter the total weekly dose of 300 mrem permitted to the blood-forming organs in the main portion of the body, to the gonads, or to the lens of the eye.

58. Air Force Procurement Instruction Sec. 7-4047. The other Department of Defense agencies probably have comparable requirements.

The Atomic Energy Act of 1954 permits private organizations to obtain source, special nuclear, and by-product material from the AEC pursuant to appropriate licenses, and by license to own and operate facilities for the production or utilization of special nuclear material.[59] Part 20 of the AEC Regulations[60] sets forth the AEC's official "Standards for Protection Against Radiation." This regulation, which applies to all persons (other than AEC contractors) under the jurisdiction of the AEC, in general codifies the recommendations of the NCRP as set forth in NBS *Handbooks* 52 and 59. In section 20.101 (a) and Appendix A it establishes maximum permissible radiation exposure for adults in restricted areas, as indicated in the table on page 419.

For minors in restricted areas and for all persons in unrestricted areas, the limits are, in general, one-tenth of the foregoing, according to sections 20.101 (c) and 20.102. Permissible concentrations of radioactive material in the air in restricted areas and in air and water in unrestricted areas are set forth in detail in special tables at sections 20.101 (b) and 20.103 and appendix B, covering some eighty-four radioisotopes and also unidentified or mixed radiation emitters. In addition, the regulation contains provisions concerning area surveys in section 20.201, use of personnel monitoring equipment in section 20.202 and posting of areas where there is a radiation hazard and marking of containers of radioactive materials in section 20.203. Sections 20.401 through 20.403 also require record keeping and reporting of accidents or loss of radioactive materials.

In addition to the foregoing, it may be worthwhile to mention in passing that the United States Public Health Service of the Department of Health, Education & Welfare probably has an emergent, although not yet clearly defined, role to play in the field of radiation protection. It has long worked closely with the AEC on health physics matters, chiefly through the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Recently it established within its Bureau of State Services a Division of Radiological Health. It is likely that in the future this Division will function in an advisory capacity for both state and federal radiation protection programs.

C. *Radiation Protection Regulation by the States*

There was some, but little, state action to regulate radiation protection prior to 1954. Passage of the Atomic Energy Act of 1954 relaxed tight federal ownership and control over many aspects of atomic energy and was intended to stimulate private atomic development. Attention then focused upon the possible need for control of the

59. Atomic Energy Act of 1954, §§ 53, 62, 81, 103 and 104, 68 Stat. 919, 42 U.S.C. §§ 2073, 2092, 2111, 2133 and 2134 (Supp. IV, 1957).
60. 57 Fed. Reg. 511 (1957).

attendant radiation hazards. Many state governments were thus stimulated into action, either adopting comprehensive regulations, sometimes pursuant to special legislation, in a manner comparable to and generally consistent with the AEC regulation for licensees, or promulgating specific regulations or statutes designed to control only certain radiation hazards.

As of the present writing, California,[61] Connecticut,[62] Massachusetts,[63] Michigan,[64] New York,[65] Pennsylvania[66] and Texas[67] have chosen to follow the comprehensive control scheme. Other states either have less than comprehensive control or none at all. Arizona and Maryland, for example, appear to have no radiation protection regulations. A number of states require radiation users to register with a state department, usually the department of public health.[68] Other states have partial regulations which are concerned with certain specific situations. Utah, for instance, has regulations governing airborne radioactivity in uranium mines.[69] Wisconsin limits certain types of radiation exposure in places of employment and public buildings.[70]

A summary of the status of radiation protection regulation in all of the states as of late 1957 appears in the *Stanford Law Review* article by Professor Frampton.[71] The Atomic Industrial Forum has recently published another such summary, which was current as of mid-1958.[72] Due to the rapidity with which developments are occurring in this field today, any such survey is likely to be out of date by the time it is published.

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61. Cal. Admin. Code, tit. 8, art. 53, 2 CCH ATOMIC ENERGY L. REP. ¶ 17,751-17,766 (1957).

62. Conn. Sanitary Code, ch. III, § 181-1-287, 2 CCH ATOMIC ENERGY L. REP. ¶ 17,791-17,809 (1957).

63. Mass. Dep't of Labor and Industries, Div. of Industrial Safety Industrial Bulletin 5, 2 CCH ATOMIC ENERGY L. REP. ¶ 17,851-17,851q (1957).

64. Mich. 1954 Admin. Code, Supp. 13, §§ R325.1301-R325.1322, 2 CCH ATOMIC ENERGY L. REP. ¶¶ 17,871-17,891 (1957).

65. N.Y. Industrial Code Rule 38, 2 CCH ATOMIC ENERGY L. REP. ¶¶ 17,901-17,973 (1955); N. Y. City Sanitary Code, art. 6, 2 CCH ATOMIC ENERGY L. REP. ¶¶ 17,974-17-974j (1958); N.Y. Public Health Reg. 16 (1956).

66. Penn. Dep't of Health Reg. 433, 2 CCH ATOMIC ENERGY L. REP. ¶¶ 18,001-18,022 (1956).

67. Texas Dep't of Health Reg. on Radiation Exposure, 2 CCH ATOMIC ENERGY L. REP. ¶¶ 18,351-18,373 (1956).

68. See S.D. Dep't of Health Reg. on Radiation Control, ch 2, 2 CCH ATOMIC ENERGY L. REP. ¶¶ 18,271-18,273 (1957). According to ATOMIC INDUSTRIAL FORUM, INC., STATE ACTIVITIES IN ATOMIC ENERGY (1958), the following additional states have comparable regulations: Alaska, Colorado, Delaware, Illinois, Kansas, North Dakota and Wyoming.

69. Utah Industrial Comm'n, General Safety Order, Reg. 2 (1955).

70. Wis. Industrial Code § 20.02(4).

71. Frampton, *Radiation Exposure—The Need for a National Policy*, 10 STAN. L. REV. 7 (1957).

72. ATOMIC INDUSTRIAL FORUM, INC., STATE ACTIVITIES IN ATOMIC ENERGY (1958).

D. *The Status of State-Federal Radiation Protection Regulations Today*

Generally, regulation to provide public and industrial health and safety is a subject within the police powers of the states. The federal government's jurisdiction in this area may arise under its power to regulate interstate and foreign commerce, its war powers, its power to control disposition of government property, or its power to attach conditions to the use of federal funds. It is interesting to note that one of the first questions which attracted legal attention in connection with state-federal regulation of radiation exposure was whether the federal government had power to control radiation exposure in private, peacetime atomic energy activities.[73] The Atomic Energy Act of 1954 was carefully drafted so as to utilize all of the broad national powers mentioned above.[74] It is doubtful that any serious question can be raised as to the constitutionality of federal regulation in this regard. Based upon such constitutional powers, the Atomic Energy Act of 1954 quite explicitly confers upon the Atomic Energy Commission the responsibility and authority for protecting public health and safety in connection with the program it administers and also the activities of private concerns which it licenses.[75]

An open question exists, however, as to whether or not the federal government has pre-empted the field of radiation protection regulation.[76] The Atomic Energy Act itself is silent on this point. In addition, the AEC has never claimed that the federal act pre-empted the field but has, in fact, offered assistance to the states in preparing state radiation protection codes. Nevertheless, to the extent that state radiation protection regulations are inconsistent with, or perhaps even consistent with but overlapping, federal regulations, they are under a legal cloud. This situation has prompted several proposed amendments to the 1954 Act to clarify state-federal responsibilities for radiation protection: the "Durham Bill,"[77] the "Anderson Bill,"[78] the "Neuberger Bill,"[79] and an AEC draft bill, which was informally submitted

73. Estep, *Federal Control of Health and Safety Standards in Peacetime Private Atomic Energy Activities*, 52 MICH. L. REV. 333 (1954).

74. Atomic Energy Act of 1954, §§ 2 and 3, 68 Stat. 918, 921 (1954), 42 U.S.C. §§ 2012, 2013 (Supp. 111, 1956).

75. Atomic Energy Act of 1954, §§ 2b, 2d, 2e, 2f, 3d, 31a, 31d, 53a, 53b, 63b, 69, 81, 103d, 104a, 104b, 104c, 104d, 161b, 161i, and 182a, 68 Stat. 918 (1954), 42 U.S.C. §§ 2012, 2013, 2051, 2073, 2093, 2099, 2111, 2133, 2134, 2201, 2232 (Supp. III, 1956).

76. See Krebs and Hamilton, *The Role of the States in Atomic Development*, 21 LAW & CONTEMP. PROB. 182, 190-91 (1956); Frampton, *Radiation Exposure—The Need for a National Policy*, 10 STAN. L. REV. 7, 22-29 (1957).

77. H.R. REP. 8676, 84th Cong., 2d Sess. (1956).

78. S. REP. 4298, 84th Cong., 2d Sess. (1956). A.S. REP. 53, 85th Cong., 1st Sess. (1957).

79. Cavers, *Legislative Readjustments in Federal and State Regulatory Powers over Atomic Energy*, 46 CALIF. L. REV. 22 (1958); S. REP. 1228, 85th Cong., 1st Sess. (1957).

to the Joint Committee in June of 1957. These proposed measures have been discussed at length elsewhere[80] and we shall not elaborate upon them here, except to note that probably none of them will be adopted in its original form.

The Joint Committee is planning hearings on this particular subject in 1959, as a result of which there may be an amendment to the Atomic Energy Act of 1954 which more clearly delineates the respective roles of federal and state governments in this field. A major purpose of this article, particularly the information presented in the following section, is to present major considerations which should, in our opinion, be reflected in the allocation of legal responsibility for radiation protection between the states and the national government.

IV. A Proposed Division of Responsibility Between the Federal Government and the States

A. *Review of Essential Factors Involved*

Any program to regulate radiation protection will necessarily involve specification of categories of radiation covered and categories of persons regulated. It will probably also deal specifically with types of radiation sources, types of activity involving radiation and radioactive materials and classification of hazards. It may make special provision for various types of facilities. The ability of any new system for radiation protection to cope satisfactorily with all these various factors will be one yardstick by which alternative proposals can be judged. We have therefore set down a number of these essential factors in tabular form for easy reference:

1. *Types of Radiation*
   a. Alpha radiation
   b. Beta radiation
   c. Gamma and X-Radiation
   d. Neutrons
   e. Heavy Particle radiation
2. *Categories of Persons Responsible for Safety in Nuclear Operations*
   a. Federal agencies and employees
   b. Contractors of the federal government and their employees
   c. State government agencies and employees
   d. Contractors of state governments and their employees
   e. Private persons and organizations with AEC licenses
   f. Private persons and organizations without AEC licenses
   g. Physicians, dentists, etc.
3. *Types of Radiation Sources*
   a. *Naturally radioactive materials*
      Uranium
      —In nature

80. Frampton, *Radiation Exposure—The Need for a National Policy*, 10 Stan. L. Rev. 7, 49-51 (1957).

—After removal from state of nature
—After concentration and refining
—Fuel for nuclear fission
—After separation of U-235 from natural uranium
Thorium
—In nature
—After removal from state of nature
—After concentration and refining
—As high temperature metal alloy
—As fertile material in breeder reactors
Radium isotopes and their decay products
—In nature (uranium ore)
—After removal from state of nature
—After concentration and refining
—In needles and capsules, etc., for medical use
—In paints and coatings to provide luminescence

b. *Materials made radioactive artificially*
Fissionable radioactive materials
—Plutonium
—Uranium-233
Non-fissionable materials
—Radioactive fission fragments
—Materials activated by neutron exposure or other processes

c. *Processes creating radiation*
Nuclear fission
—Subject to continuous control—as in reactors
—Not subject to continuous control—as in weapons
Nuclear fusion
—Subject to continuous control—as in reactors
—Not subject to continuous control—as in weapons
Particle acceleration
Electron bombardment—as in X-ray machines and fluoroscopic devices
Nuclear reactions—as in polonium-beryllium neutron sources

4. *Types of Activity Involving Deliberate Creation of Radiation or Use of Radioactive Materials*

a. *Military applications*
Nuclear weapons
—Research and development
—Manufacture
—Testing
—Stockpiling
Fissionable material production and separation
Nuclear propulsion for ships
—Powerplant research, development and testing
—Nuclear ship operations
Nuclear propulsion for aircraft, rockets, missiles, etc.
—Powerplant research, development and testing
—Vehicle operations
Nuclear propulsion for land vehicles

—Powerplant research, development and testing
—Vehicle operations
Nuclear power generation equipment
—Research, development and testing
—Operations
Food preservation by radiation sterilization
—Research and testing
—Production operations

b. *Civilian applications (non-medical)*
Use of nuclear reactors for
—Power generation
—Research and testing
—Production of radioisotopes
—Process heat
—Propulsion
—Other
Use of radioisotopes for
—Industrial applications
—Agricultural applications
—Other
Use of industrial X-rays
Use of radioactive metals as alloys
Use of electronic equipment emitting radiation
Use of particle accelerators in research
Educational activities involving training in handling of radioactive materials, reactors, etc.
Transportation of radioactive materials

c. *Medical applications*
Diagnostic and therapeutic use of X-ray and fluoroscope machines
Use of external radiation from natural and artificial sources, for research, diagnostic and therapeutic purposes
Use of radiation doses taken internally for research, diagnostic and therapeutic purposes

d. *Nuclear fuel cycle*
Uranium and thorium mining and milling
Feed materials processing
Gaseous diffusion separation
Chemical processing
Metallurgical processing
Fuel element fabrication
Chemical reprocessing of irradiated nuclear fuel
Radioactive waste disposal

5. *Types of Radiation Exposure Hazard (Including Normal Operation and Accidents)*

a. *Class I.A.—Possible harm limited to persons and property in immediate vicinity of nuclear operations—radiation levels relatively low*
Use of X-ray machines and fluoroscopes
Use of low-level radioisotopes where there is no possibility of internal exposure
Use of source material as metal alloy

Creation of radiation by certain radar, T.V. and other advanced electronic equipment
Mining and milling of uranium and thorium

b. *Class I.B.—Possible harm limited to immediate vicinity of nuclear operations—but radiation levels relatively high*
Use of high level radioisotopes
Use of radioisotopes where internal exposure is possible
Use of high voltage particle accelerators
Fuel element fabrication

c. *Class II.A.—Possible harm not limited to immediate vicinity of nuclear operations—radiation levels relatively low*
Low level radioactive waste disposal
Use of low power research reactors

d. *Class II.B.—Possible harm not limited to immediate vicinity of nuclear operations—radiation levels relatively high*
Chemical separation of U-235
Production reactor operations
Nuclear weapons testing
Power reactor operations
Test reactor operations
High power research reactor operations
Military propulsion reactor operations
Chemical reprocessing activities
High level radioactive waste disposal

6. *Types of Facilities*

a. *Nuclear fuel cycle facilities*
Mines and mills
Feed materials plants
Separation plants
Chemical processing plants
Metallurgical processing plants
Fuel element fabrication plants
Chemical reprocessing plants
Waste storage and disposal facilities

b. *Nuclear weapons facilities*
Fissionable material production facilities
Weapons fabrication plants
Weapons storage bases
Weapons test sites

c. *Military propulsion facilities and vehicles*
Reactor manufacturing plants
Reactor testing stations
Nuclear powered ships and their operational bases
Nuclear powered air and space vehicles and their operational bases
Nuclear powered land vehicles and their operational areas

d. *Military nuclear power stations for field use*
Reactor manufacturing plants
Reactor testing facilities
Operational reactors

e. *Food irradiation facilities*

f. *Central nuclear power stations*
g. *Nuclear research and experimental testing facilities*
Particle accelerators
Gamma source facilities
Research reactors
Test reactors
Nuclear materials laboratories
(Note: Research and development laboratories may be associated with almost any of the other facilities listed. They may be separate facilities by themselves. They may also be part of an educational or medical institution plant.)
h. *Process heat reactors*
i. *Isotope production reactors*
j. *Facilities where radioactive isotopes are used*
(Note: Radioisotopes may be used almost anywhere without special facilities.)
k. *Medical centers using X-ray machines and radioisotopes*
l. *Transportation equipment employed for shipment of radioactive material*

B. *Possible Theories About Division of Responsibility Between National and State Governments*

Is it desirable to divide the responsibility for radiation protection between the federal government and the states? Let us first examine the position of the federal government. National responsibility for many radiation hazard producing activities is too well established and accepted to permit complete withdrawal from the field in favor of the states. Nuclear operations associated with nuclear weapons research, development, manufacture, testing and stockpiling is an integral part of our national defense program. The same is true of nuclear operations related to use of atomic power for ship propulsion, air and space craft propulsion, land vehicle propulsion, and power generation for military field operations. It is therefore necessary and proper for the federal government to retain full responsibility for controlling the radiation hazards associated with such activities—and to do so on an exclusive basis.

If one grant that the federal government is properly in the business of regulating radiation protection, is it necessary or appropriate for the states also to regulate in this field? Professor Frampton has ably argued that dual control by federal and state governments is unworkable as a practical matter, that an over-all national program is essential, and that the most logical course is pre-emption of the field by the federal government.[81] The states, through grants-in-aid, or similar devices, would participate only in the enforcement and inspection of the national program on terms laid down by Washington. If he is right in concluding that a single, over-all national radiation protection

81. *Id.* at 7.

program is essential, we agree that the national government, probably acting through the AEC (but possibly through the Department of Health, Education and Welfare), is the proper agency to discharge this responsibility.

Prior to World War II, however, the states had full responsibility for radiation protection regulation—with the exception of interstate transportation of radioactive materials. Today the states still have exclusive responsibility for regulation of radiation from non-fission sources, namely, X-ray machines, fluoroscopes, particle accelerators; from naturally radioactive substances not regulated by the Atomic Energy Act, primarily radium; from source material prior to its delivery to the Atomic Energy Commission; and from a not yet clearly defined assortment of electronic equipment, such as certain advanced television and radar sets, which are beginning to emerge as radiation emitters. None of these radiation sources presents a widespread public health risk; rather, any risk from their use is limited to persons in their immediate vicinity. These sources are industrial health hazards, circumscribed in area of potential harm.

Unless there really is a paramount need for a single, uniform, over-all radiation protection program covering all persons and all types and sources of radiation in all of the various types of applications, facilities and circumstances where radiation is purposefully involved, we believe it is best for the states to retain jurisdiction over those aspects of radiation protection which have no significant interstate or national aspects.

The reasons advanced in favor of an over-all centrally directed national program boil down principally to two:

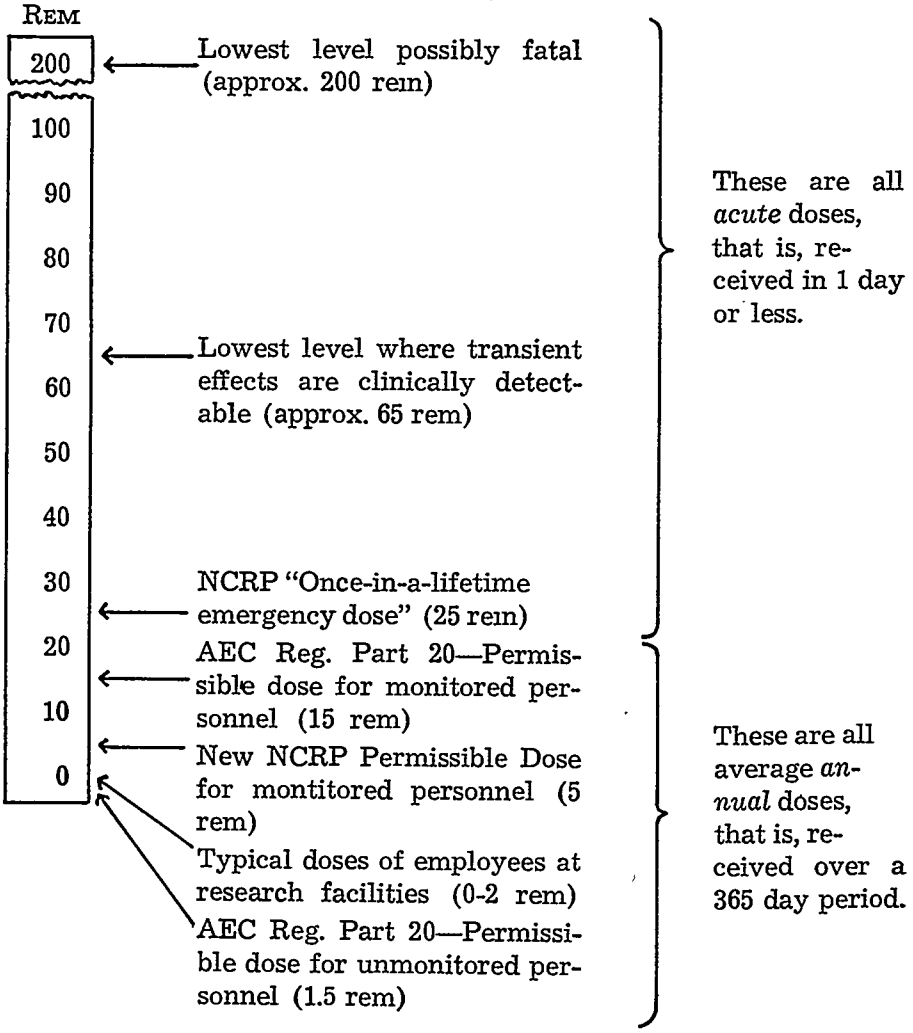
(1) The basis for all regulation is the standard maximum permissible dose to the individual and the standard maximum permissible concentration of radioactive material that may be released without further control back to the environment; these standards are based on scientific considerations; where there is a variance between jurisdictions—as there is likely to be if the states are permitted to set their own standards—the validity of all standards will be cast into doubt. Equipment manufacturers will be obliged to meet conflicting requirements. And the process of adjusting to standards which are revised from time to time by the scientific community will be multiplied by the number of jurisdictions involved.

(2) Ours is a peripatetic society. Radiation exposure has a cumulative effect. The only way to keep track of the total exposure received by any given individual who moves from state to

state is to have a uniform standard throughout the country (if not, indeed, the whole world) and uniform cumulative exposure records. Without such procedure nobody's cumulative dose can be known with certainty or controlled effectively.

The fallacy of the first reason mentioned above is that it ascribes greater quantitative significance to the concepts of "maximum permissible dose" and "maximum permissible concentrations for uncontrolled release to the environment" than is warranted. It implies a black-and-white distinction that does not in fact exist. Perhaps this point can best be illustrated graphically:

External Exposure



Remember, first, that the radiation exposure we are here discussing is occupational and plant-environs exposure which constitutes only about five per cent of the total radiation exposure to which the population is being subjected.

Disregarding genetic effects for the moment, one can see from the above chart that the maximum dose of 15 rem per year allowed by the present AEC regulations is well below the dose that one must receive in order to have clinically detectable transient effects even when received in an acute dose, that is, all within twenty-four hours. The new NCRP recommendations are even lower. With respect to injury to the individual exposed, the margin of safety is already so great that minor variations in specific maximum permissible dose standards pale into insignificance. It is comparable to a difference in speed limit between five or ten miles per hour when the speed that is dangerous is sixty miles per hour. As a matter of fact, for over a year the AEC itself has been administering two different standards: five rem average annual dose for AEC contractors, fifteen rem for licensees. This discrepancy, which looks large because it is a factor of three, has not caused any dislocation of the atomic energy program to our knowledge. If, then, one state were to take the five rem standard and another a ten rem standard, the inconsistency would not cause a greater hardship.

A second reason why meticulous uniformity of permissible dose is not important is that the techniques and instruments used for personnel monitoring are not presently so refined that one can determine exactly how great a dose any given individual has in fact received. Any dosimeter worn or carried by a person will, of course, register only the radiation that strikes it. Unless the circumstances of exposure are known and under special control at the time, it is assumed that the individual received the same dose to his entire body. Obviously this is only an approximation. If he wears the dosimeter in a shirt pocket it may record the radiation that approaches him at his face fairly accurately. If the radiation is from behind, the shielding effect of his body will reduce the recorded dose. Both direct-reading dosimeters (electroscopes) and film badges have this limitation. When one also takes into account the limits of calibration accuracy, the limits of accuracy in reading the film or instrument, and the difference between absorbed tissue dose and "instrument dose," the best over-all accuracy one can obtain is on the order of 50-90 per cent (depending on the dose levels involved) for film badges and about 80 per cent for direct-reading dosimeters. Because radiation exposure cannot be controlled down to the last millirem, and because the dose one receives cannot be determined by personnel monitoring methods until

after the exposure has occurred, carefully planned health physics programs keep all exposures to a minimum. This is ordinarily well below NCRP maximum permissible doses. In fact, it was this practice of keeping occupational exposures well below permissible levels that made it possible for the NCRP to revise its standards downward without causing serious difficulties.

Even less do considerations of genetic injury require exact uniformity between states. We have previously mentioned how obscure are the causal links between radiation exposure and genetic injury. While lowering of the NCRP maximum permissible dose from fifteen to five rem per year on the average was based upon recommendations of geneticists, it reflected the basic concept that the best dose is no dose. Since the state-of-the-art of radiation protection had progressed to the stage where a reduction of the maximum permissible levels by two-thirds had become feasible, such reduction became ipso facto desirable, particularly when dealing with unknown consequences, such as genetic injury. Nevertheless, occupational and plant-environs exposure still constitute only a small fraction of the total population exposure to radiation. The recent reduction recommended by the NCRP will have only a slight effect in reducing total population dosage. And minor variations from state to state will have a negligible effect.

Accordingly, we do not believe non-uniformity in maximum permissible dose between states is calamitous, once one appreciates the nature of the standards involved. Variation in standard will not cast doubt as to whether one is right and another is wrong. Both lie in an area of discretionary judgment. Nor does the plight of the equipment manufacturers appear too difficult. In the first place, the only equipment involved is that having to do with personnel exposure. Such equipment is a small fraction of all nuclear equipment sales. In the next place, there does not appear to be any reason why the manufacturer cannot, if he is mass producing such a product, set his specifications to meet the strictest standard. He will find that most of his customers prefer to comply with the strictest standard even if not required to do so. And he will find his competitors are facing the same problems he has. We recognize that the problem of the equipment supplier exists; however, it does not appear to us to be significant. We likewise recognize that the process of adjusting to revised standards will be made more difficult in proportion to the number of jurisdictions involved. That a greater time lag will be involved is inevitable. However, if one will agree that exact uniformity is not essential, then the non-uniformity caused by changing standards is no cause for alarm.

We do not mean to imply that uniformity is not desirable. It ordinarily is, and probably is here too. Lack of uniformity, however, is acceptable under the special circumstances that obtain in the field of radiation protection regulation. Furthermore, it seems likely that substantial uniformity will be achieved informally. The states that have adopted regulations thus far have all worked closely with both the NCRP and the AEC. The industrial concerns that form a portion of the persons to be regulated have the opportunity to express themselves in favor of uniformity either directly to the state officials or indirectly through participation with the American Standards Association.

The second major reason advanced in favor of an over-all national program is that only such a program can cope with the mobility of the population in this country today. The thought is that cumulative lifetime exposure records are needed. Such records are impossible unless radiation protection regulation standards are uniform and the records kept are uniform.

In examining this reasoning closely, let us first bear in mind that the only persons we are talking about are workers at establishments using radiation sources and keeping individual personnel exposure records. We are not considering members of the public generally, nor even those who linger at the plant fence and receive exposure. No records are kept for such persons. Their protection lies in the rule that they are not permitted to receive more than one-tenth of the maximum permissible dose for monitored personnel. Such persons could remain at the fence indefinitely without receiving a dose of sufficient magnitude to cause them "appreciable bodily injury."

Our concern here is for the worker who is monitored. It seems self-evident that what is important here is not uniformity of radiation protection standards, and not even uniformity of record keeping, but rather availability of records. If you are an employer in State *X* hiring a nuclear employee from State *Y*, the only regulation that concerns you is that in State *X*. You comply with that regulation. When you hire the employee, you want to know what his radiation exposure history is, so that you will know whether he can be assigned to an area where he may be exposed. Whether or not his cumulative exposure to date exceeds the limits of State *Y* is irrelevant. Whether the limits in State *Y* are the same as in State *X* is likewise irrelevant. And in view of what we have previously said about the effects of non-uniformity of standards, probably any lack of uniformity is also immaterial.

Uniform records would be of help in this situation. However, the second employer can always take data furnished by the first employer and put it into such form as he desires. The biggest problem

that occurs in this situation appears to be that of obtaining any data at all from the first employer. Health physicists quizzed on this point have consistently reported that some organizations are very willing to cooperate in this regard and some are not. Failure to cooperate is often due to the idea that the records are confidential as far as the employee is concerned and should not be divulged without his express permission. When this is the case, usually the prospective new employee will provide the required consent. In some cases failure to cooperate is attributed to "company policy" and records are not made available even when the employee does consent. This causes the second employer to speculate whether the employee might in fact have received an overdose which his prior employer preferred not to reveal. Congress could solve this problem by requiring an employer to furnish such records upon request of a prospective or actual new employer. The power to regulate interstate commerce would certainly seem adequate to justify such a statute. In any event, the real problem is not uniformity of regulatory standard, nor uniformity of record keeping, but availability of records.

As the foregoing discussion indicates, we are not persuaded that the circumstances of radiation protection regulation necessitate preemption of the field.

Our next question is whether the field is intrinsically divisible, and, if so, how it should be divided. Section A above listed major features involved in radiation protection regulation. Any one of them could serve as a basis for division of responsibility, *e.g.*:

1. Types of Radiation
   States—Alphas and betas
   U. S. —Gammas, neutrons, heavy particles

2. Categories of Persons
   States—State agencies, employees, and contractors; private persons and organizations with and without AEC licenses; physicians, etc.
   U. S. —U. S. agencies, employees and contractors

3. Types of Sources
   States—Thorium, radium, activated materials, particle acceleration, electron bombardment, nuclear reactions
   U. S. —Uranium, plutonium, fission fragments, fission, fusion

4. Types of Activity
   States—Civilian applications, medical applications
   U. S. —Military applications, nuclear fuel cycle

5. Types of Hazard
   States—Classes I.A., I.B., II.A.
   U. S. —Class II.B.

6. Types of Facility
   States—Central power stations, process heat reactors, isotope production reactors, some R & D facilities, isotopes, medical facilities
   U. S. —Fuel cycle facilities, weapons facilities, military propulsion facilities and vehicles, military power stations, food irradiation facilities, some R & D facilities, transportation equipment

It is apparent that some of the above categories would be better than others as the basis for dividing the field and that probably no one alone is adequate. Other possible ways of dividing the responsibility can undoubtedly be suggested. The way that appears to us to be most promising is described in the following section.

C. *Recommended Division of Responsibility Between the States And The Federal Government*

In our estimation the most straightforward way to ascertain whether and where a line can be drawn between federal and state jurisdiction for radiation protection is first to determine the bounds within which there is a paramount national interest, sufficiently great to justify exclusive jurisdiction by the federal government. As we see it, the area of any such paramount national interest will be defined by:

(a) The needs of national defense,
(b) Matters of interstate significance, and
(c) Matters in which the federal government has a direct financial interest.

Radiation protection regulation which is not directly related to at least one of the above criteria should be left to state jurisdiction.

To control radiation hazards, one must control the materials and machines which produce ionizing radiation. The category, "Types of Radiation Sources," noted above in section IV.A. will therefore best serve as the basis for our present discussion. Our attention will be directed at first to the possession and use of such materials, excluding their transportation. The subject of their transportation will be given separate treatment subsequently.

Uranium: Natural uranium (which contains both U-235 and U-238) is important strategically as our primary source of fissionable material. Uranium ore is mined and milled primarily by private concerns. Then the AEC buys it and sends it to feed materials processing plants.

After this process it can be used as fuel for natural uranium reactors or it can be sent to a gaseous diffusion plant where the proportion of U-235 to U-238 is increased to whatever extent is desired for the particular purpose to which it is to be put. After being used in a reactor for a period of time uranium fuel becomes "poisoned" by build-up of fission fragments which will ultimately prevent the fission process from occurring. The "spent" fuel is then sent to a chemical reprocessing plant where the fission fragments are separated out and the usable uranium recovered. Among the usable fission fragments are U-233 and plutonium, both of which are, in turn, fissionable. Nuclear weapons use plutonium, primarily. Reactors can use U-235, U-233 or plutonium.

Natural uranium is classified legally as "source material."[82] Plutonium, uranium-233, and uranium enriched with U-233 or U-235 are classified as "special nuclear material."[83]

The AEC's radiation protection program presently includes all persons possessing or responsible for use of source material, subsequent to AEC purchase of the milled ore,[84] and all persons possessing or responsible for the use of special nuclear materials.[85] Persons who possess the uranium or plutonium do so either as government contractors or as AEC licensees, subject to Part 20 of its Regulations.

Radiation protection in connection with the possession and use of uranium or other special nuclear materials in support of our weapons program is rightly within the exclusive jurisdiction of the AEC. Such activities are intimately connected with our defense program. The same is true of possession and use of uranium and other special nuclear materials in support of the AEC's reactor development program.

Use of uranium and plutonium for private reactors, whether the reactors are for research, testing, power production or isotope production, is indirectly, if not directly linked to our national defense. Their use requires appropriation out of the national stockpile of fissionable materials. And operation of these reactors is regulated by AEC license, to be sure—among other matters—that the user will not divert any fissionable material he possesses or creates to an improper use.

Furthermore, the United States had a direct financial interest in the safe operation of many, if not all, of these reactors. Under the Price-

82. Atomic Energy Act of 1954, § 11.x, as amended, 71 Stat. 576 (1957), 42 U.S.C. § 2014 (Supp. V, 1958).

83. Atomic Energy Act of 1954, § 11.y, *op. cit. supra.*

84. Atomic Energy Act of 1954, § 63, 68 Stat. 933 (1954), 42 U.S.C. § 2093 (Supp. V, 1958).

85. Atomic Energy Act of 1954, § 53.e, as amended, 71 Stat. 576 (1957), 42 U.S.C. § 2073 (Supp. V, 1958).

Anderson Amendment to the 1954 Act[86] the AEC now furnishes indemnification up to five hundred million dollars for public liability arising out of nuclear incidents caused by privately owned and operated AEC licensed facilities. Thus any nuclear incident at such facilities is likely to result in direct costs to the federal government. Finally, with the large reactors particularly, there may be possibility of multistate harm, resulting from widespread fission fragment deposition in the event of a reactor excursion. Each of these reasons supports exclusive federal responsibility for radiation protection control over the use of uranium and other special nuclear materials in private reactors.

The Atomic Energy Act of 1954 presently requires the AEC to investigate the safety of all such reactors and to license their operation only if no undue risk to the public is involved.[87] The AEC has a Reactor Hazards Evaluation Staff and Reactor Safeguards Committee which pass on the safety of each reactor in the country. Safety analyses for a nuclear facility, particularly one of a new design, are highly technical and complicated. The AEC already has some of the best available minds in the country at its disposal for this service. Consequently, there is also a practical reason why to leave the AEC with exclusive jurisdiction over safety of design and operation of all reactors.

A somewhat similar position is occupied by private organizations which prepare nuclear fuel for private reactor operations. These concerns perform chemical and/or metallurgical processing upon natural uranium or enriched uranium. They also fabricate fuel elements. No possible interstate hazard is involved, however, and it is optional with the AEC whether to grant Price-Anderson indemnification for such concerns when operating under AEC license. Nevertheless, because of the practical considerations noted above, and the indirect, if not direct, connection with defense, it would appear best to assign exclusive responsibility for radiation protection regulation of such operations to the AEC.

Uranium and plutonium are used in two other contexts that deserve special mention. The first is in research laboratories. Relatively small amounts of U-238, U-235, U-233 and plutonium are frequently needed for experimental research. Virtually no defense aspects, no interstate features, and no direct federal financial interest are involved. It would therefore seem best to leave responsibility for radiation safety for such use to state governments.

The second context is commercial use of these materials other than

86. Atomic Energy Act of 1954, as amended, 71 Stat. 576 (1957), 42 U.S.C. § 2012 (Supp. V, 1958).

87. Atomic Energy Act of 1954, § 103d, as amended, 70 Stat. 1071 (1956), 42 U.S.C. § 2183 (Supp. V, 1958) and § 104d, 68 Stat. 937 (1954), 42 U.S.C. § 2134 (Supp. V, 1958).

for reactors. Plutonium in a sealed container has been used as a light source in some electronic equipment. Uranium could, presumably, be used in a similar application. Perhaps these materials will be found valuable in a metal alloy for some special use. The federal interest here seems quite remote. It would therefore appear best to leave radiation protection regulation of such situations to the states.

We previously mentioned that at present the AEC radiation control program attaches to the use of uranium after purchase of the ore by the AEC. Radiation safety in uranium mines and milling operations is presently left to the states. We see no reason why this arrangement should not continue.

Thorium: Thorium is naturally radioactive. Its strategic importance lies in the fact that it is a "fertile material" which can be used in a reactor to produce U-233.

Thorium is classified as a "source material."[88] Essentially the same considerations apply to it as apply to natural uranium. The federal government should maintain radiation safety responsibility for thorium in connection with its processing (after purchase by the AEC) and its use in reactors. The states should be responsible for safety regulations of possession and use of thorium prior to delivery to AEC; in laboratories; and when used other than in reactors, as in magnesium-thorium, a high temperature metal alloy.

Radium: Radium isotopes have a series of radioactive decay products, none of which are fissionable material. Neither the Atomic Energy Act of 1946 nor the act of 1954 assigned the AEC any responsibility for providing safety from radiation from radium. There does not appear to be any reason of national defense, interstate implications or national financial interest which would justify transferring jurisdiction for radiation safety for radium from the states to the federal government.

Artificially made radioactive materials: Some artificially made radioactive materials are fissionable, namely, U-233 and plutonium. These are classified as special nuclear material.[89] Responsibility for radiation protection in their use should be handled in the manner as "Uranium," described above.

In addition to the foregoing, there is an almost endless variety of other materials that can be made radioactive, though not fissionable, by artificial means. Almost any material will become radioactive to some extent upon exposure to neutron radiation. Activation is most easily accomplished using a reactor, but can be accomplished using a particle accelerator. Another type of artificially radioactive material is the radioactive fission fragments that build up in the nuclear fuel in a

88. Atomic Energy Act of 1954, § 11.x, *op. cit. supra* note 82.
89. Atomic Energy Act of 1954, § 11.y, *op. cit. supra* note 83.

reactor core during nuclear operations. Upon reprocessing of the fuel, these radioactive materials are separated from the re-usable uranium and plutonium. They may then be considered waste products and disposed of, or they may be packaged and used. Such materials, if produced by neutron activation, will be first in the possession of the person with whose machine they were activated. If obtained from fuel reprocessing, they will be in AEC possession at the outset.

With the exception of waste disposal, it is highly doubtful that use of these radioactive isotopes falls within the area of national interest as defined by national defense, interstate implications, or national financial interest. In the past AEC responsibility for radiation safety in their use resulted from the AEC's role as radioisotope distributor. Congress gave the AEC authority to make by-product material available to licensees only if the recipient would observe AEC safety standards.[90] "By-product material" is defined in the 1954 act as "any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material."[91] It includes non-fissionable, artificially radioactive materials produced and distributed by the AEC and by AEC licensees. It does not extend to identical radioisotopes produced with privately operated non-licensed accelerator equipment. Thus present AEC responsibility in this area is not based upon a careful balancing of whether the states or the federal government should have the governmental responsibility for regulating radiation protection in the use of this type of radiation source. Rather, it is based upon the idea that the AEC should look out for any risk to the public health and safety resulting from the use of any such sources distributed by the AEC.

There is one good reason why the states should be assigned this responsibility. Uses of radioactive isotopes in industry are already widespread and are increasing each year. If the AEC is to retain jurisdiction for all health and safety associated with radioactive by-product material, it will soon have an obligation to keep track of operations in every agricultural, industrial and medical establishment of consequence in the United States. It would therefore appear much more practical to have this responsibility exercised by the state and local governments.

Disposal of radioactive waste (which is normally by-product material but can include source and special nuclear material) is a more complicated matter. It is usually accomplished by one

90. Atomic Energy Act of 1954, § 81, 68 Stat. 935 (1954), 42 U.S.C. § 2111 (Supp. V, 1958).
91. Atomic Energy Act of 1954, § 11.e, 68 Stat. 922 (1954), 42 U.S.C. § 2014 (Supp. V, 1958).

of three techniques. The waste may be diluted to safe levels and dispersed back into the environment by dumping it into sewers or into the air by exhaust stacks. Or the waste may be concentrated and confined in "burial vaults," not to be released to the environment until its radiation levels have lowered to safe levels by passage of time and natural decay of radioactivity. Or it may be dumped in the ocean, using containers to prevent dispersal for some interval of time and then relying upon the ocean to provide dilution.

Such radioactive waste disposal appears to involve three distinct orders of magnitude. The greatest quantity of most highly radioactive waste is collected at the AEC's reprocessing plants. The next greatest quantity of fairly highly radioactive waste is accumulated in connection with operation of reactors and other nuclear facilities. Here there are not only the fission fragments (which are normally unseparated from the nuclear fuel) but also, in the case of research, test and isotope production reactors, materials intentionally irradiated and made radioactive. The third level of magnitude is the waste disposal of by-product material which has been supplied to industrial, agricultural, medical and other concerns and which has become useless for one reason or another.

To us it appears advisable to assign the responsibility for radiation protection regulation of the first two categories to the AEC and to leave the third to the states. Waste disposal has an inherently interstate quality. Radioactive materials disposed in sewers ultimately find their way to interstate waterways and the ocean. Radioactive material diffused into the atmosphere will not remain over the state where it was released. Radioactive materials buried in the ground may get into underground water supplies. There is a danger that waste of permissibly low concentrations from one source will combine with like waste from another source and produce contamination levels that are too high. This situation supports the argument that *all* radioactive waste disposal should be under federal control. However, it is believed that the third category of by-product material uses mentioned above generates such a small quantity of radioactive waste and that the level of its radioactivity is so low that there is no appreciable interstate hazard involved. If the volume and/or radioactive levels of such waste ever become high enough to have a significant interstate impact, the federal government should be given exclusive control over all radioactive waste disposal.

Nuclear Fission: In the process of nuclear fission there is a considerable release of direct radiation in addition to the radiation normally emitted by the radioactive material present. Under present law facilities in which controlled fission can occur fall under the rubric either

of "production facility" or "utilization facility."[92] They must either be owned by the federal government and operated for it or licensed by the AEC.[93] Responsibility for radiation protection control over all operations of reactors and other production and utilization facilities should probably remain with the federal government. The reasons for this conclusion are given under the heading of "Uranium" above.

Nuclear Fusion: The only practical use developed to date for nuclear fusion has been nuclear weapons. Much study is being expended upon ways to achieve fusion under conditions of continuous control. Some of this study is privately financed. Most of it is AEC financed. When machines or processes are developed which permit continuous fusion to be sustained, operation of the machine or process will be subject to the same AEC licensing, safety analysis, and Price-Anderson indemnity as fission reactors. Accordingly, we believe radiation protection responsibility for fusion operations should be assigned to the federal government.

Particle Acceleration: Certain machines are designed to accelerate charged particles of the atomic nucleus. These accelerators are used primarily for research, but are also used for medical therapy. The hazard they present is limited to persons in the immediate vicinity. No national defense, interstate aspects or federal investment is involved. In the past the responsibility for regulating their safety has been left with the states. No reason is now apparent for changing this arrangement.

X-Ray Machines and Fluoroscopes and Other Electronic Equipment: X-ray and fluoroscope machines are in very widespread use by doctors, dentists and hospitals for medical diagnosis, therapy and research. They are also used in certain industrial applications. Radiation created by their use is hazardous only to persons in the immediate vicinity. The same is true of some advanced types of electronic equipment which emits some radiation incidental to normal operation. Like particle accelerators these radiation sources have previously been subject to control only by the states. Like accelerators their use does not involve any paramount national interest. Any regulation to assure safety in their operation should therefore remain with the states.

Nuclear Reactions: The final type of radiation producing process to be mentioned is the nuclear reaction. A good example of this is the juxtaposition of polonium and beryllium in such a way that the alpha

92. Atomic Energy Act of 1954, § 11.t, as amended 71 Stat. 576 (1957), 42 U.S.C. § 2014 (Supp. V, 1958).

93. Atomic Energy Act of 1954, § 91, 68 Stat. 936 (1954), 42 U.S.C. § 2121 (Supp. V, 1958) and § 101, as amended, 70 Stat. 1071 (1956), 42 U.S.C. § 2131 (Supp. V, 1958).

radiation from polonium (a radium decay product in some forms) reacts with beryllium to release neutrons. One use of this reaction is to provide neutrons as reactor starter sources. Other reactions may be similarly used. Probably such reactions are also used in nuclear research and possibly for industrial applications, such as chemical catalysis. No paramount federal interest is involved. Consequently, we believe the states should be responsible for any safety regulation applicable to use of such reactions, except where such use is part of reactor operations.

Radioactive Material Transportation: Transportation of radioactive materials was expressly excluded from the foregoing discussion. The federal government will necessarily maintain jurisdiction over interstate carriers. The only real question is whether the states should be given the responsibility for radiation protection in intrastate shipments. The criteria of paramount national interest which we have been using throughout do not seem very relevant in this situation. Clarity for its own sake is probably the best guide here. Locating the point at which intrastate commerce begins and interstate commerce ceases is probably a hopeless task. If we were to use this distinction as a basis for establishing jurisdictional bounds between states and the federal government, there would always be a grey area in which neither government could be sure of its own authority or of the authority of the other. Accordingly, it would appear to be best to assign to the federal government jurisdiction for radiation control over all transportation of radioactive materials. Has Congress the power to give federal agencies jurisdiction over radiation protection regulation for instrastate transportation? In our opinion it has. Certainly if it has the power to pre-empt the whole field, it has power to pre-empt one small corner of it.

D. *A Challenge for Cooperative Federalism*

In the foregoing discussion we have recommended our plan to divide responsibility for radiation control between the states and the federal government, by reference to all major sources of ionizing radiation. Attention must now be directed to some associated questions which were not considered above:

(1) Would the respective jurisdictions of state and federal governments be mutually exclusive? Or would they be concurrent, and if so in what areas?

(2) Would U. S. government facilities or contractors be subject to state regulation?

(3) Would a single private facility be subject to regulation by both state and federal governments at the same time?

These questions pose a challenge for cooperative federalism. Is it possible for the states and the federal government each to recognize that the over-all matter of radiation protection regulation involves a host of controls over a variety of types of radiation source, categories of atomic energy activities and legal classifications of persons and facilities to be regulated—part of which is so closely related to paramount national interests that federal control is essential and part of which is so unrelated to national interests that federal control is not warranted? Can this rather complicated field be clearly divided, so that part is the responsibility of the states and part the responsibility of the federal government, without ambiguity, without gaps, without overlapping, unless done for a purpose? Does the federal government have enough confidence in the states to permit them to establish their own programs governing situations where the national interest is slim or non-existent—even though they may differ from the federal standard and from one another? Can the federal government tolerate state regulation and inspection of the federal facilities and contractors with respect to that area of radiation protection responsibility assigued to the states? Or will the federal government permit the states to function in the field only on condition their regulations in no way affect the federal government? Will there be "give-and-take," or will it be all "take"? This is the challenge of *cooperative* federalism. And this is the question Congress will have to decide when it amends the Atomic Energy Act of 1954 to clarify who is responsible for what in radiation protection regulation in the United States today.

There are several policy guidelines which we believe come into play in this situation. Some of these were noted in the preceding sections. Others were implicit. Altogether they are as follows:

(1) Unless the subject of radiation protection is so indivisible or so interrelated that the only sensible program is a single, over-all national program, the federal government should be responsible for regulation only in areas where there is a paramount national interest. The states should be responsible for the remainder.
(2) Paramount national interest should be defined in terms of national defense, interstate implications and direct national financial investment.
(3) The line of demarcation between federal and state jurisdiction should be as clear and simple as possible.
(4) There should be no gaps between the respective jurisdictions of the states and the federal government. Overlapping jurisdiction should be avoided. If not, areas of overlap should be clearly identified.

(5) Insofar as possible, each person regulated should be answerable to only one government agency.
(6) Consistency and uniformity of radiation protection standards and personnel monitoring records is desirable.

We believe the best approach is to have mutually exclusive areas of jurisdiction assigned to the federal government and the states. A fairly clean-cut division of the field can be accomplished in the manner described above. Separate and exclusive jurisdiction by each government will avoid unnecessary duplication. By focussing responsibility clearly, it will minimize the chances that a particular hazard is not properly controlled because each regulatory agency thought the other was looking into it. It can provide a basis for mutual respect, trust and interchange between federal and state officials involved. It will avoid the present unsatisfactory situation in which states are passing comprehensive regulations, overlapping the federal regulations, casting doubt in the minds of persons being regulated whether they are subject to dual regulations on the same point and imposing enforcement obligations on state agencies sometimes in excess of their budgetary or other capabilities.

If two, mutually exclusive jurisdictional areas are established, should AEC facilities and AEC contractors be subject to or exempt from state regulation as to matters generally within state jurisdiction? In the converse case, *i.e.*, AEC regulation of state agencies and contractors, it is clear that no exemption from federal regulation is in order. The area of federal jurisdiction is established by reference to certain paramount national interests. Such interests will exist no less where the party regulated is a state government or one of its agencies or contractors.

The reverse is not true, however. The area for state jurisdiction is established as that in which there is no significant federal interest—when considering private parties as the subject of regulation. If the federal government is the party to be regulated, at least two federal interests are involved: (1) the cost of compliance with the regulations, and (2) the submission to authority not created by Congress. When a federal contractor is involved, the federal interests involved are extra contract cost due to contractor compliance with state regulations, and some loss of control over the contractor's activities.

This situation is closely related to the case of the private party who is subject to federal regulation with respect to part of his operations (research reactor operation, for instance) and state regulation with respect to another part (by-product material in the laboratory, for instance). It is definitely advisable from the point of view of the party regulated to have only one agency with which it has to file reports

and by which it will be inspected. A good procedure might be to have one agency, state or federal, be the "primary regulatory agency" with respect to the party or installation involved. The federal agency would have to be given the power of choice whether it or the state agency should be the primary regulatory agency in any given case, since the federal agency would be custodian of the national interest. Once such a selection is made, the primary regulatory agency could then be the repository for all reports that are required and make all inspections to insure compliance with the regulations. The primary regulatory agency could inform the secondary agency in whatever detail the secondary agency requires. In this manner both state and federal regulations can be effectively administered.

Federal facilities and contractors could be handled in the same fashion. If the contractor's only use of radioactive materials is within the area for state jurisdiction, the AEC (assuming it is the federal agency) could elect whether to allow a state agency to enforce its regulations against the contractor or whether to undertake the enforcement aspects itself and notify the state officials. The same procedure could be followed for federal facilities. By giving the AEC power of decision whether to be the primary regulatory agency, all national interests can be assured. By having the state regulations apply to all persons, without exception for federal contractors and facilities, the simplicity of jurisdictional division is retained. We believe this procedure would offer one practical solution to the problem of how to have separate state and federal jurisdiction over radiation protection and yet have a simple, clean-cut system that does as little violence to federal-state relationships as possible.

V. SUMMARY

Radiation protection regulation is a subject in which both the states and the federal government have a legitimate interest. The subject is not monolithic; federal pre-emption of the entire field is not necessary or particularly desirable. Aspects of radiation protection regulation of particular importance to the federal government can be clearly identified and responsibility therefor assigned to one or more federal agencies. Other aspects, not of significance to the federal government, should be classified as a state responsibility. The following table summarizes a recommended division of authority between state and federal governments:

U. S. Government	*States*
All source material being used or processed in the nuclear fuel cycle after purchase by the AEC	All source material and its use prior to its purchase by the AEC, *i.e.*, mining and milling
All special nuclear material being used or processed in the nuclear fuel cycle or in nuclear weapons	Laboratory use of source and special nuclear material
	Commercial use of source and special nuclear materials other than for reactors
	All radium isotopes and their decay products
By-product materials in the possession of operators of production and utilization facilities, and reprocessing plants and disposal by such operators of radioactive waste resulting from such operations	By-product material use and radioactive waste disposal by persons other than operators of production and utilization facilities and reprocessing plants
Production and utilization facility design and operations—both fission and fusion	
	Particle accelerators
	X-Ray Machines, Fluoroscopes and Advanced Electronic Equipment
	Nuclear Reactions
Transportation of radioactive materials	

The division of jurisdiction should be exclusive. However, as to persons whose activities are under the jurisdiction of both state and federal regulations, the federal agency should elect whether to be the primary regulatory agency or whether to ask the state agency to perform such function. Thereafter the primary regulatory agency should be the sole point of radiation regulation enforcement and inspection, with all reports filed with such agency and all inspections made by its personnel. The primary regulatory agency should provide the secondary agency with any information the latter desires concerning radiation protection regulation compliance by the regulated party.