REGULATION OF RADIATION EXPOSURE BY LEGISLATIVE MEANS

Handbook 61

U. S. Department of Commerce
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National Bureau of Standards • A. V. Astin, Director

Regulation of Radiation Exposure by Legislative Means

Recommendations of the
National Committee on Radiation Protection

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Preface

This report represents something of a departure from the recommendations on radiation protection that have been prepared in the past by the National Committee on Radiation Protection. For the most part each of the reports prior to this one has presented technical facts and data and from these has developed certain specific recommendations as to methods and procedures for the achievement of adequate protection of persons against the harmful effects of radiation.

This Handbook presents the problem of radiation in relation to its possible control by State or municipal authorities. The problem is a very new one to all except two or three States. At this time, only one State has a set of comprehensive regulations designed to control all forms of ionizing radiation; a few others are developing such regulations.

Until about 1950 it was the accepted policy of the National Committee on Radiation Protection that it discourage the incorporation of its recommendations into legislative or other similar control acts. It was felt that better results could be obtained through education and voluntary compliance. In most respects the committee still feels this way, but also it recognizes that conditions are changing rapidly and that State control may become a necessity with the accelerating growth of radiation uses.

The National Committee on Radiation Protection has now adopted the policy that it will not recommend or oppose the incorporation of its findings into State codes. However if a State decides, of its own volition, to develop radiation-control legislation regulations, the committee will provide any assistance within its capabilities—to the end that the regulations may be made as sound and workable as possible. A further aim is to assist the several States in the matter of assuring the maximum degree of technical and operational uniformity between their several radiation regulations.

The NCRP studies of the radiation-control problems, resulting in the present report, were begun early in 1953. The subcommittee on the "Regulation of Radiation Exposure" was organized as a result of a joint request by representatives of the American College of Radiology, the American Medical Association, and the U. S. Public Health Service. This request was prompted by repeated inquiries by individuals and groups seeking guidance and information on the subject.

It is hoped that the material in this report will provide a convenient and suitable basis for the development of uniform radiation-control regulations that can be used by our several States where the need for regulation may be felt. There has been close coordination between this committee and the AEC in their development of radiation regulations under the Atomic Energy Act of 1954. The principal differences between the Federal regulations and those of the National Committee on Radiation Protection lie in the fact that the AEC regulations pertain only to radiation sources as defined in the Atomic Energy Act, whereas the NCRP regulations cover *all* sources of radiation, including radium, X-ray machines, and high-energy accelerators. No attempt is made in this report to resolve the jurisdictional problems that will almost surely develop between Federal, State, and municipal authorities in their efforts to control or regulate the use of ionizing radiations.

The National Committee on Radiation Protection (originally known as the Advisory Committee on X-ray and Radium Protection) was formed in 1929 upon the recommendation of the International Commission on Radiological Protection. The Committee is sponsored by the National Bureau of Standards and governed by representatives of participating organizations. Eleven subcommittees have been established, each charged with the responsibility of preparing protection recommendations in its particular field. The reports of the subcommittees are approved by the Main Committee before publication.

The following parent organizations and individuals comprise the Main Committee:

American College of Radiology: R. H. Chamberlain and G. C. Henny.
American Dental Association: R. J. Nelsen.
American Industrial Hygiene Association: E. C. Barnes and J. H. Sterner.
American Medical Association: P. C. Hodges.
American Radium Society: T. P. Eberhard and E. H. Quimby.
American Roentgen Ray Society: T. C. Evans and R. R. Newell.
National Bureau of Standards: L. S. Taylor, Chairman, M. S. Norloff, Editorial Secretary, and S. W. Raskin, Secretary.
National Electrical Manufacturers Association: J. A. Reynolds and E. D. Trout.
Radiological Society of North America: G. Failla and R. S. Stone.
U. S. Air Force: S. E. Lifton, Maj.
U. S. Army: E. A. Lodmell, Col.
U. S. Atomic Energy Commission: J. C. Bugher and K. Z. Morgan.
U. S. Navy: C. F. Behrens, Rear Adm.
U. S. Public Health Service: H. L. Andrews and E. G. Williams.
Representatives-at-large: Shields Warren, J. L. Weatherwax, and H. B. Williams.

The following are the subcommittees and their chairmen:

bcommittee 1. Permissible Dose from External Sources, G. Failla.
bcommittee 2. Permissible Internal Dose, K. Z. Morgan.
bcommittee 3. X-rays up to Two Million Volts, H. O. Wyckoff.
bcommittee 4. Heavy Particles (Neutrons, Protons, and Heavier), H. H. Rossi.
bcommittee 5. Electrons, Gamma Rays, and X-rays above Two Million Volts, H. W. Koch.
bcommittee 6. Handling of Radioactive Isotopes and Fission Products, H. M. Parker.
bcommittee 7. Monitoring Methods and Instruments, H. L. Andrews.
bcommittee 8. Waste Disposal and Decontamination, J. H. Jensen.
bcommittee 9. Protection Against Radiations from Radium, Cobalt-60, and Cesium-137 Encapsulated Sources, C. B. Braestrup.
ıbcommittee 10. Regulation of Radiation Exposure, L. S. Taylor.
ıbcommittee 11. Incineration of Radioactive Waste, G. W. Morgan.

The present Handbook was prepared by the Subcommittee n Regulation of Radiation Exposure. The following are ıe subcommittee members and the organizations by whom ıey were designated:

. S. Taylor, Chairman, National Committee on Radiation Protection.
. E. Chamberlain, American Medical Association.
. C. Hodges, American Medical Association.
. R. Newell, American College of Radiology.
. P. Pendergrass, American College of Radiology.
. G. Terrill, Jr., U. S. Public Health Service.
. D. Trout, National Committee on Radiation Protection.
. Western, U. S. Atomic Energy Commission.
. G. Williams, U. S. Public Health Service.

The committee wishes to acknowledge with appreciation he efforts of more than a hundred attorneys, engineers, adiologists, scientists, and others who have offered many ıelpful comments and suggestions to the subcommittee in he course of preparation of this Handbook.

A. V. Astin, *Director*.

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Regulation of Radiation Exposure by Legislative Means

1. Summary and Conclusions

1.1. The Problem

The problem under discussion is the one of possible injury to human beings due to the peaceful use of ionizing radiation. The problem is not new. It has been under continuous study by national and international groups of able specialists for many years.

Radiation is injurious to living things. The kinds and degrees of injury vary widely according to the kind of organism exposed and the kind and amount of radiation. Advances in science now make it possible to state the health hazards of radiation fairly accurately. Recent developments of sources of radiation, including radioisotopes, and multiplication in their uses, industrial as well as medical, make the associated health hazards more and more important. As health hazards from disease are brought under better control, the hazards not yet well controlled rise in relative importance and begin to warrant greater efforts to abate them. The medical uses of radiation still predominate, and physicians should be the persons best able to know the hazards and guard against them. Through their professional societies, they have accomplished much in codifying the requirements for radiation safety. The occasional emergence of injury and disease (leukemia) attributable to irradiation indicates the incompleteness of voluntary protective measures. The use of X-rays in industrial operations is even more likely to be incompletely controlled, because it is more often outside the observation of those prepared by education and experience to appreciate the hazards.

These things may imply that some degree of statutory control of radiation hazards is becoming necessary. In fact several States and a few municipalities have legislated in regard to some of the hazards. If such legislation is assumed to be desirable, or at least inevitable, then it should make use of what is already known about radiation and the methods that have been found useful by radiologists and radiation hygienists or health physicists.

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If the wisdom were great enough, the statutes would undoubtedly be much alike. Some degree of uniformity is justified on its own behalf; but as perfect wisdom is lacking and as different communities have somewhat different problems, a variety of statutory approaches is inevitable and perhaps desirable.

1.2. Possible Solutions

Possible solutions to the problem may lie anywhere between a hands-off policy and a totally restrictive legislation. Neither extreme would be in the best interests of national welfare. The aim should be to bring about effective protection from the radiation without restricting its use in valid applications.

There appear to be three policies worthy of consideration.

The least restrictive solution, yet one that might prove most effective in the long run, would be one following present broad policies augmented by a widespread program of education. The present policy has much to recommend it; under it the AEC screens all applicants and applications for radioisotopes, and the various medical and industrial bodies carry on educational and advisory programs for their members. The expansion of this program through more intensive education in the widening areas of use is a possible solution well worth careful consideration.

A second possible solution would be one in which all sources of radiation are registered. If the registrant or the proposed use seemed questionable, necessary steps could be taken to inspect and advise as to proper protecting procedures. Given the proper cooperative atmosphere this arrangement would place little restriction on the valid use of ionizing radiation. In general the user would watch his own practices carefully, knowing they were open to inspection.

The third and most restrictive solution would be one calling for inspection and licensing of all radiation sources. It would be costly and difficult to administer. It does not lend itself to cooperative effort on the part of the control agency and the user. It is not recommended.

1.3. Statement of Broad Considerations

Statutes and codes or regulations should be enforceable within the willingness of the vast majority of the affected persons to submit to control, and with the funds that legislatures are willing to appropriate. Every unenforceable provision weakens the effect of the other provisions, which

might in themselves be enforceable. Provisions that entail high administrative costs, like compulsory inspection and licensing, may leave too little money for activities that would save more lives.

Statutes should be as simple as possible, leaving the details to codes or regulations, which can be changed by administrative methods that are easier and quicker than statutory amendment.

Such flexibility is essential in view of the likelihood of (a) continuing growth of scientific knowledge, (b) technical improvements in the art of radiation hygiene, (c) increased public acceptance of control through bettered education and emotional reaction to threats of atomic and radiological warfare, etc., (d) changing relative importance of other hazards—epidemic and sporadic diseases, industrial accidents, traffic accidents, etc., and (e) changing political philosophy and complexion that alter the moneys available for enforcement.

The several fields of radiation hygiene (e. g., irradiation of employed personnel and of casual persons; pollution of water and air and ground) should be covered in one statute and put in one administrative office rather than dividing them among several departments.

2. Philosophy of Radiation-Protection Legislation

2.1. Introduction

1 The problem of protecting persons from the harmful effects of radiation (X-rays, gamma rays, beta rays, alpha rays, neutrons, etc.) has existed since their first discovery. In the early days of gas tubes, protective measures were almost nonexistent; but not many people were exposed. During World War I the use of X-ray equipment expanded rapidly through the introduction of the Coolidge tube, and an alarming increase in radiation injuries was noted. Reasonably effective measures were very soon developed to cope with the problem.

2 Until about 1925 the principal uses of radiation were in the medical field. From then on industrial uses increased rapidly and at the same time higher and higher energies were developed for use in medicine, industry, and research. Until about 1943 harmful effects of radiation were limited mainly to the patient, doctor, technician, or industrial worker. It could scarcely be regarded as a public health

problem, though it was beginning to become an occupational health problem.

3 After radioactive isotopes were made available in quantity and variety never before imagined, it became clear that within a very few years radiation protection had become a serious public health problem not only occupationally but generally. An additional problem, recently developed, has been more of a psychological nature. In large measure because of the public press, part of the lay population has developed an exaggerated notion of the seriousness of the problem. (This report deals only with peacetime uses.) This has, at times, resulted in almost panicky efforts to eliminate or reduce it.

4 The means are available to control the hazard. The prime necessity is to give the public a factual understanding of the dangers and their avoidance, in proper perspective with the usefulness of radiation. Education is essential. Human nature being what it is, legislation may also be needed; but it is certainly our opinion that we cannot legislate ourselves out of our difficulties.

5 For many years it has been the informal attitude of the National Committee on Radiation Protection and the International Commission on Radiological Protection that radiation legislation is not only unnecessary but might be definitely harmful. Consequently their efforts have been directed toward the development of basic protection data and information and, for certain areas, codes of safe practice. With the rapid growth of the protection problem over the past 10 years it appears to some that these efforts alone are inadequate, and they have resorted to control by legislation.

6 The problem in the U. S. is different from that in a country with a single centralized government. In the extreme, 48 different types of radiation regulations could be developed. For the nation as a whole this would be a chaotic and uneconomical situation. It is our endeavor therefore to aid the States in arriving at a common understanding of the problem—to the end that regulation, if any, may be developed along reasonably uniform lines. As a further aid to those States or municipalities feeling the need for radiation regulation, we are suggesting which features should be included and which are undesirable.

2.2. The Need for Control of Radiation Exposure

7 Radiation is silent, unseen, and unfelt; its presence can be made known only by means of instruments. Some of its damaging effects on the human system may not develop until may years after exposure. Therefore radiation hazards cannot be treated like some of the common hazards. The lay mind has consequently developed a fear that in some cases is quite inordinate. In most States the matter of industrial accidents is pretty well threshed out; most accidents are sudden and only predictable on a probability basis. On the other hand, many radiation injuries are cumulative and gradual, and the hazard measurable. The understanding of these injuries and the technics for measuring the hazard belong to a relatively small group of scientists.

8 Legislators and administrators have to depend on medical and biophysical scientists to guide them in drawing the line between what is permissible and what is not. Engineers and architects can then plan the features needed for protection. But there do not exist in the whole country enough radiation safety specialists to support, for all States, the degree of radiation regulation envisioned presently by one or two States.

9 Regulation has to encompass many kinds and sources of radiation. Care must be taken that rules for one use do not conflict with those for another. One must have in mind X-rays and all the different nuclear radiations, tubes operating at 10 thousand volts to 25 billion, and the multifarious uses in three categories: medical, industrial, and research. In trying to control a source of hazard one must not completely block a desirable use. Medical and research uses especially would suffer from ill-considered restrictions: the former because application of radiation to a person is actually the desired use, and the latter because unpredicted applications are the soul of research.

10 Any effective law is likely to work to someone's disadvantage. The disadvantages should be foreseen, weighed against expected benefits, and ameliorated if possible. These considerations may vary in different States, or be differently evaluated. National legislation is not the cure for interstate conflicts, because police powers are reserved to the States.

2.3. Enforceability of Radiation Legislation

11 Before any program of radiation legislation is begun, one of the most important aspects to be considered is that of enforcement. Some proponents of legislation feel that just to have laws on the statute books is a step forward. It is true that laws are occasionally established for what amounts to educational purposes, and in this regard may be useful even if never enforced. This is not a widely accepted practice nor do we recommend it. It is our considered opinion that unless the laws are to be enforced, they should not be promulgated. One must therefore evaluate in advance the many factors that will enter into an enforcement program—financing and staffing being the two most critical ones.

12 Let us assume that some State has a rigorous and detailed law designed to regulate radiation exposure and the use of radiation sources. What then is probably the principal problem of enforcement? Most people would agree that plant inspection would provide the most direct means of assuring compliance with the law. To be completely effective such inspection would have to be on a 100-percent basis, i. e., every existing, new, or altered radiation source should be examined. This would certainly be ideal, but in most States would be impossible of attainment.

13 Granting that 100-percent inspection cannot be realized except possibly in some restricted circumstances, what then is the substitute? Probably selective spot checking is the best we can hope for. If the existence of all radiation sources within a given jurisdictional area were known, the control authority could have within its power the inspection of any installation at will. The knowledge on the part of an operator that such inspection could occur at any time would probably be the strongest incentive toward compliance with accepted safety practices. On the other hand this threat would have to be backed up by so sufficiently broad an inspection program that the individual chances of being inspected were fairly high—perhaps 1 in 5. If the inspections were inadequate, the fact would soon become known and some operators would "take their chances."

14 In addition to inspection, the followup procedures must be positive. Where faulty operation is discovered, suitable corrective measures must be required and reinspections performed by the control agency. Failure to follow through could undermine an otherwise good program.

15 In the area of radiation control the existence of State laws and a regulatory body serves not only for policing, but more importantly—even if indirectly—as a center for education, consultation, advice, and general prophylaxis. To inspire the proper respect and confidence the Agency must be staffed with suitably trained personnel. To do otherwise would give a false sense of security to radiation users. At present, the conscientious user is himself responsible for the safety of his own operations. With the existence of a regulatory body he still has the responsibility but will lean more and more upon the control group to assure him that his precautions are adequate. Poor advice or careless or superficial inspection may allow unsafe operations to continue until harm is done. Thus a control organization that is thought to be strong, but in fact is not, can conceivably result in more harm than no organization at all. This should be clearly recognized in the development of legislation. Even if the control has to be developed by stages, the law should be confined to those things that can be clearly and properly enforced from the outset. It might be wise to place in the law some language that would make it possible to delay putting certain provisions into effect, without recourse to special legislative action. This procedure would tend to develop confidence in the enforcement authorities, whereas allowing a time-lapse before enforcement would have the opposite effect. No matter how good a law is, if everyone knows that for practical reasons it cannot or will not be enforced, there results a climate of hostility or helplessness, in which it may be next to impossible to get anything effective done.

16 An accurate assessment of the total task is necessary in order to determine its feasibility. Financial uncertainty or instability can ruin an organization in its childhood. Because there is nothing more difficult than to reestablish an agency that has publicly failed, it is essential that it be organized properly and financed adequately from the outset.

17 A radiation-control body can be financed in one of three ways: (1) by fees paid by the user, (2) by appropriated funds, and (3) a combination of fees and appropriated funds. There are advantages and disadvantages to all three. From the point of view of the general public the fee system would no doubt receive strong support, because it does not increase taxes. However it would suffer from instability.

A State regulatory operation cannot be conducted like a profit-making business. Consequently it would be difficult to insure adequate operating and reserve funds. Problems of fee collection, seasonal variations, etc., would make operational planning difficult, at least at the start. Efforts to overcome these could result in the control Agency's trying to make business for itself. This is a dangerous policy and could lead to much abuse and subsequent criticism. On the other hand, with time, the fee basis would probably expand, and with efficient operations the unit fee should decrease. Care should be taken lest the fees be made so large that small users suffer hardship. A fee system should not be started with the prime objective of tapping a new source of revenue.

18 The second method is the simplest but might not appeal to the taxpayer who sees little direct benefit to himself. Except for radioactive-waste disposal the average person is not likely to be exposed to radiation; the main beneficiary is the radiation worker; or at least so would go the arguments. Actually in the long run the taxpayer may benefit by not having service charges added to the cost of using radiation in his behalf. An operation supported by appropriated funds could have reasonable stability and working capital, and so be better able to attract the technical personnel needed.

19 The combination of appropriated funds and fees probably offers the best solution. The basic stability could be provided through annually appropriated funds. Fees could then be nominal or on the basis of actual cost. Certain tests carried out by governments will, at times, cost more than can reasonably be charged the recipient. In many such cases it is not unreasonable to make a lesser charge and let the taxpayer bear the additional cost as an indirect beneficiary.

20 In the combination plan, funds adequate for the complete operation would be appropriated. Moneys developed through fees would then go back directly to the treasury and not be used for current operations of the regulatory body. To do otherwise might tempt overzealous control bodies or individuals to go after business in order to build up their own little empires, an obviously unsound practice that could discredit and undermine the operation. Philosophies on this subject appear to be controversial.

21 One may ask why we dwell on the points above—particularly that of funding. It is simply because technico-legal operations are difficult at best, and it is only by adequate advance consideration of such questions that control legislation can be properly framed. For success, the laws must be developed to fit the existing facts as far as known, and the practical situations as far as predictable. The legislation should compel as little readjustment as possible.

22 Many instances will occur in which interested parties will desire to make substantial contributions in money or materials in the interests of developing a stronger program. This is to be encouraged, for it is a saving to the taxpayer, and it tends to hold the active interest of the public. Legislative provision should be made for the Agency to accept such gifts or bequests. Compulsory publicity for such gifts could be expected to assure their honesty of purpose.

2.4. Licensing Versus Registration

23 If the use of radiating equipment and materials is to be controlled, the procedures should be adapted as much as possible to our national temperament. The NCRP thinks that voluntary control based on adequate education often may prove best. However, here we are dealing with legislation as it may prove necessary. The least requirement recommended is registration of every use of radiation; to require less is to insure that the Agency remain in ignorance of some uses. Inequitable and inefficient control then becomes inevitable.

24 The licensing of radiation usage is presently required in a few countries outside of the U. S. None of the States has a radiation-control statute that requires licensing (although some did in their initial drafts). A few municipalities require licensing of certain types of radiation equipment.[1] When one asks why licensing is required, the answer is almost invariably that it provides the control authorities with a knowledge of where radiation exists. Compulsory registration can accomplish that much and does not involve the same complexity as licensing. By proper penalties, failure to register can be made suitably unprofitable. The only advantage of licensing over mere registration is that abatement of improper use is simpler by withdrawal of license than by petitioning a court for an injunction.

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[1] I. R. Tabershaw and S. J. Harris, Administrative problems in radiation protection, Nucleonics **12,** No. 12, 8 (1954).

25 It is true that by requiring the issuance of a license before the fact, some unsafe operations may be prevented from starting, yet this argument is rarely advanced. Practically all such situations could be discovered and stopped in plenty of time under registration. One of the strongest arguments against licensing is the magnitude of the task; it is so enormous that the nation as a whole lacks the radiation experts necessary to implement it. Legislation requiring licensing and approval would probably be unenforceable for a long time to come; and this alone would throw the remainder of the program into disrepute. Registration, on the other hand, does not involve advance approval or subsequent implied approval and could be carried out in an orderly manner without undue strain on any regulatory body.

26 The effectiveness of voluntary radiation control should not be overlooked even where a State Agency has radiation-control powers. In many States, there are large radiation installations better equipped to deal with radiation control than the State itself. It may be wise to grant them blanket authority to solve their radiation-control problems in ways essentially of their own choice, unless or until they should prove to be ineffective. Examples of instances in which this approach might apply would be the Radiation Laboratory of the University of California (university), Knolls Atomic Power Laboratory (industry), and the National Bureau of Standards (government).

27 Up to the present time, four major efforts leading to radiation control have been undertaken by States. One State order, which has been in effect for several years, requires neither license nor registration. Another calls for registration along lines proposed in this report. A third proposes registration in a manner so elaborate that it almost amounts to licensing. A fourth proposal calls for registration of all radioactive sources of activity greater than background. Superposed on these will be the almost certain federal licensing of AEC-produced radioisotopes. Confusion is well on its way.

2.5. Constitution of a Radiation-Regulation Body

28 The type, size, and structure of a State radiation-regulation body depends upon the basic philosophy adopted for that particular State. The basic philosophy and the organization are inextricably related, and in the initial

stages they must be worked out together. The degree to which inspection is carried out depends upon the size of the inspection organization the State is willing to support. The size of the organization depends upon the quantity, distribution, and nature of radiation sources in the State. The availability of trained manpower will influence the planning. A logical starting point would be an assessment of the radiation sources, yet this cannot be obtained without some type of organization. It would appear that the initial organization should be simple and flexible and expandible. The regulations should be amendable by executive action and nothing should be included that cannot be completely enforced from the outset. The coverage can be broadened if necessary, when the increased need indicates and our knowledge advances. Under these circumstances the program will acquire respect.

29 A law to control radiation would be completely ineffective without a realizable enforcement body. The initial planning should be devoted to the organization, which may be incorporated within some existing State department or agency. This expansion of activities involves considerable speculation; but with some degree of technical advice, the order of magnitude of the problem can be established for both immediate and long-range objectives. One of the most important items to consider from the very outset is the degree to which responsibility for enforcement is delegated or referred. For example a philosophy that calls for a control body to inspect and regulate directly and continuously all sources of radiation will necessitate a vastly larger body than will a philosophy that leaves compliance with regulations solely to the individual user, with only spot checking by the control Agency.

30 It is our opinion that for practical reasons any successful radiation regulation will lie between the two extremes above, and probably somewhat nearer the one based on voluntary compliance. This point of view colors the discussion that follows.

31 States will undoubtedly differ in philosophy, but certain fundamental aspects will be common to all States; these should dominate the development of an ideal regulatory program, if it is to be widely acceptable. Some of the variables are listed, but need not be discussed in detail.

32 1. Geographical size of State. For the larger States, loss of expert time due to travel will necessitate a larger

organization, other factors being the same. Duties requiring considerable travel make it difficult to obtain the services of specially trained persons. Travel costs must be considered in the budget. Many State and Federal programs have been reduced to low effectiveness through legislative skimping on travel funds.

33 2. Population. This in itself has little influence on radiation control. On the other hand population distribution is an important factor. Large urban concentrations will involve problems quite different from those where population density is low. Some States will have both. Higher density of radiation sources can be expected in big cities.

34 3. Degree of industrialization. Generally this is closely associated with population. The radiation-protection problem will increase roughly in proportion to the total industrial activity.

35 4. Presence of specialized industry. In addition to direct atomic-energy operations, contributory industries may develop radiation-protection problems, either directly or through possible contamination of air and water. Other special industries may make extensive use of radiation from fixed sources (i. e., accelerators or sealed radioactive sources) where the general public will not be affected.

36 5. Classified operations. A wide variety of such operations exists in installations throughout the country. Some plants require total security and States will have little or no jurisdiction in such areas. Other operations involve partial security, that is, both classified and unclassified work; and access to the restricted areas will probably be denied to State inspectors. What control, if any, will States have over such operations? It is certain that States should have something to say about air and water contamination outside the operation areas. Answers to some of these questions may come from the interpretation of the 1954 Atomic Energy Act.

37 6. Federal Government operations. In addition to the large-scale classified operations mentioned above, Federal Government laboratories employing radiation sources are located in many parts of the country. What jurisdiction will the States have here? In general the control of radiation in these areas is adequate for present needs, but the States may have a legitimate interest in the control of radiation hazards that may spread

beyond the geographical limits of Federal Government operation sites. At a later date, with increasing competence of State organizations, it may be desirable for them to take an active part in radiation-hazard control on some Federal Government sites. The Act or regulations under the Act should clearly define the relationship between State and Federal jurisdictions. We are not yet in a position to make recommendations regarding these relationships.

38 7. Medical uses. All medical uses of radiation should be subject to the same general control as industrial or research uses. The fact that radiologists and physicians presumably know a great deal about radiation hazards should not exclude them from control. On the other hand, great care should be exercised to avoid any possible interference with medical practice, either by intent or implication.

39 It has already been mentioned that it seems preferable to develop any radiation regulation within or around some existing State agency. Persons with some competence in radiation matters may be found in such State agencies as Public Health and Labor.

40 The shortage of trained personnel will be a problem for many years. This, if nothing else, should militate against starting an over-ambitious regulation program in which even the minimum requirements cannot be enforced. Unskillful inspectors can be dangerous through neglect, or very costly to the user through overzealousness. In many areas, an inadequately trained person will quickly be detected and his presence will breed contempt for the regulations and the whole program. By including the regulation program in an existing organization having some experience with radiation, the possibility of such occurrences will be minimized.

41 Eventually the Agency should train its own personnel; at present no State organization is prepared to do this. Specific authority and funds should be granted to enable the organization to send certain key people to nationally recognized radiation-training centers or universities to receive training not available elsewhere.

42 A final factor favoring incorporation in an existing organization is the saving of overhead costs. Much of the paper work and housekeeping services needed by a radiation-protection program would be common to other protection programs and the same office management frequently could serve both.

2.6. The Development and Use of Advisory Services

43 The country has a large number of scientists engaged in various forms of radiation work, but mere experience with radiation does not necessarily produce wisdom in matters of radiation protection. It is a sad fact that some notable radiation injuries over the past few years have occurred to highly trained radiation researchers. Extensive experience in the field is necessary for the development of an understanding and philosophy of the over-all problem. Few States will be able to attract into full-time service the experienced experts whose guiding influence is essential to the success of a radiation-protection program. It is therefore wise to use the best experts available in a consultative capacity. It is recommended that an advisory body of radiation-protection experts be made an integral part of any legislative plan. The duties of such an advisory board (hereinafter referred to as the Board) and the authority for its establishment should be clearly described in the Act.

44 For the Board to be successful, the demands upon the time of its members must be kept to a minimum—perhaps a few days a year, except at the installation of the new program. By bringing to the Board only problems of a most technical nature, and treating the lesser problems at staff level, there is the best assurance of getting and holding an effective advisory group of radiation-protection experts. To burden them with trivial problems would develop a situation leading to abandonment of the work by the very people whose services are needed.

45 In many cases, it may be desirable or necessary for the Board to include some members from outside the State in order to bring its technical competence to a maximum level. These cases may necessitate special legislation.

46 In order that the Board members may feel free to devote sufficient time to the problems, they should be paid a fee and reimbursed for travel and extra living expenses. Consultant fees should be in keeping with the earnings of experienced scientists, but not so large as to tempt scientists to accept the duty just for the pay. Unless the scientist is sufficiently motivated by the opportunity for accomplishment, the value of his consultation is uncertain—at any price.

47 As already emphasized, the Board should be asked to act only on matters of prime technical importance or in cases of controversy. The members cannot be expected to perform any of the operational or routine work. Unless the

Agency itself can rule capably on the vast majority of routine situations, the program should not be undertaken in the first place. Board meetings should be scheduled perhaps three or four times a year. An advance agenda should be made available to the Board members so that they have all the essential facts and data at hand for their consideration before the meeting. The Board members could be compensated for time spent in such preparatory work.

48 It would be appropriate for the Board to consider problems of organization and administration where they touch on technical matters. However, it should be spared routine administrative problems.

49 No operating responsibility should be vested in the Board. Its duties and functions should be regarded as advisory and the full responsibility for implementing any recommendations should rest with the Agency. By this means is avoided any overlapping of authority, which could easily be very confusing if both Agency and Board had power to act. The concentration of each member's efforts along the lines of his specialty will permit maximum utilization of the limited skilled manpower available for such consultative boards.

2.7 The Development of an Objective State Radiation-Protection Act

50 A State radiation-protection Act must be adapted to the structure and practices of the government of that State. It should define the scope and responsibility, and either set up the necessary authority or designate the existing governmental department that will be responsible for its execution. It should scrupulously avoid technical details, but should establish the procedure by which such details are worked out, implemented, and revised to meet changing conditions. In this way a high degree of flexibility can be attained—a feature that we regard as critically essential to the success of any radiation-control program.

51 Technical considerations can be covered in the form of regulations or orders, which each State may make as detailed as desired. The Act may well make specific reference to nationally accepted codes. If these appear too complex, the State may prepare its own by extracting key features from them. This is shown in considerable detail later in this report. It is mentioned here to show the value of flexibility.

52 The outstanding advantage of such an Act is that the implementation can be gradual. It avoids the impotence of an Act set up with great detail but providing for inadequate implementation. It also avoids the breakdown likely to occur with overly ambitious implementation for which it proves impossible to recruit the trained personnel. We cannot overemphasize our belief that a small complete success is far more important than a big partial success, let alone a big failure.

53 The extreme that we think should be avoided is a "specificity" Act that, in addition to the essential features outlined above, would include details of organization, implementation, technical data, specific exposure limits, etc. The disadvantage of such rigidity should be readily apparent. In the matter of permissible exposure limits alone, it may be pointed out that during the past 25 years this committee has watched the evolution of protection philosophy develop and it has changed many times. A specificity Act giving permissible exposures in 1930 would have had to be amended half a dozen times to keep abreast of modern advances. An Act of 1950 would now require its second modification. This has actually been happening in one State.

54 A specificity Act must, of necessity, be complete in detail and positive in language. It must be free from legal loopholes and ambiguities and yet, at the same time, anticipate every conceivable situation that may arise under its operation. This is difficult enough in areas of great public experience. In the field of radiation, legislative and practical experience are relatively meager and the technical matters complicated and sometimes controversial.

55 The process of devising or revising a law full of technical details may be very elaborate. It involves extensive hearings, many of which hinge on highly technical matters and language that is foreign to the average lawmaker. There is every likelihood of making a law that is technically unenforceable. It seems wise to avoid this by leaving such matters to technical experts operating within the framework of a broad Act.

2.8. Radiation-Protection Experts

56 The success of any radiation-control program depends strongly upon the choosing and training of persons qualified to perform the necessary field and laboratory work. Reports of the National Committee on Radiation Protection and

American Standards Association refer to them as "qualified experts," and the American Board of Radiology as "radiological physicists." The latter group represents the only nationally recognized registry of persons broadly qualified in the fields of radiation dosimetry and protection. The qualifications are high and the number is so small that few of the registrants would be available for State radiation-control work.

57 The present certification by the American Board of Radiology was designed to meet a different need from that envisioned for the operation of a radiation-control plan. Diplomates of the American Board of Radiology are serving medical radiologists, and are required to have clinical experience. Hence they are overqualified for the purpose at hand. Enactment of radiation-control legislation will necessitate having a much larger pool of "qualified experts," but the standards should be different from those set by the American Board of Radiology. The latter, for instance, do not seek to develop the perspective necessary for large-scale radiation health programs.

58 Important sources of radiation-protection experts are the AEC training centers at Oak Ridge, Hanford, and Rochester. Although many graduates of these schools may be eminently qualified as radiation specialists for State work, most cannot qualify before the American Board of Radiology because of the lack of clinical experience.

59 It is unfortunate that no national plan exists for the certification of radiation experts of the type that will be needed by the State programs. New York State plans to establish its own certification and registry along lines similar to those used for registered engineers.

60 Some uniformity of standards for "qualified experts" is obviously desirable between the various States. The National Committee on Radiation Protection has been wrestling with this problem for many years but has accomplished little, as it was not constituted in a manner that would permit actual establishment of a program. It may be feasible to develop standards and requirements and, by working cooperatively with State authorities, to assist in bringing about their general acceptance.

61 It is obvious from our discussions that the range of knowledge and experience required of the qualified expert will be considerable and it is hardly to be expected that more than a very few individuals will be expert in all phases. It

may be necessary, therefore, to certify them for particular phases only, so that they will not be called upon to provide services for which they are not qualified. This certainly complicates the certification problem, but appears to be unavoidable.

2.9. Laboratory and Instrumentation Program

62 Any program of enforcement requires certain specialized facilities and equipment for determining the existence of radiation hazard, contamination, damage, etc. Little, if any, of this will be found within existing State organizations. The facilities required will, of course, depend upon the extent of the planned program. In turn, the program will be determined, to some degree, by how far the State wishes to go in providing special facilities. A few of the special items are mentioned here, although this is not to imply that they are necessary to start a program.

63 Film-badge service would require special temperature-controlled film-processing equipment not customarily found in hospitals or X-ray installations. Equipment for producing the calibration control exposure would be needed, together with high-quality photometric densitometers. Skilled technicians would be needed to perform the work. It is, of course, possible to purchase such services through a commercial organization.

64 Analysis of atmosphere and breath for radon may be called for in the dial-painting and related industries, uranium mining, etc. It requires highly specialized facilities not readily obtainable on the market, and specially trained technicians. This service is not widely available commercially. Limited facilities in laboratories of the Atomic Energy Commission, Public Health Service, National Bureau of Standards, and Massachusetts Institute of Technology are mainly designed for their own purposes and are not generally available to the States.

65 Other specialized equipment and specially trained technicians may be needed to measure the extremely small amounts of other isotopes that may accumulate in the body or appear in urine and feces.

66 Analysis for airborne particles of radioactive material, determination of surface contamination, assay of contaminants of unknown composition, radioactive water analysis—just to mention a few areas—all require special facilities. It is possible that limited services in some of these areas may be commercially available within a few years.

67 Portable or semiportable types of survey instruments are required for general field use. These include instruments for measuring X- and gamma rays, alpha rays, beta rays, and neutrons. Calibration and standardization facilities generally available to the public exist only at the National Bureau of Standards. The State may require some relatively simple secondary facilities for insuring that these instruments are in proper working order at all times. Expenditures for laboratory facilities can range from a few thousand to some tens of thousands of dollars.

2.10. Items Included in Existing or Proposed Radiation-Control Acts or Regulations

68 Examination of existing Acts and present proposals dealing with radiation control show numerous elements in common. The order of their appearance varies considerably, presumably to conform to the legal practice of the State or country concerned. We discuss below some of the elements that are of particular importance.

69 (a) *Policy.* An important element of an Act is its initial statement of scope, application, purpose, policy, or whatever term may be used to explain the aims of the Act. It is noted that most of the orders or Acts avoid such a statement and launch at once into the functional details. This almost would make it appear that the State was faced with situations of criminal intent, that all radiation was evil, and that something drastic should be done to curb its use. In actual fact radiation is now an essential part of our civilization; its importance to medicine, research, and industry is beyond estimate, and in the vast majority of situations radiation is being used safely. If the matter of radiation protection and control is presented in its true perspective, the program will undoubtedly be more readily accepted. Reduced to the simplest terms the problem can be stated as "An Act to avoid radiation injury without interfering with the desirable uses of radiation."

70 A suggested statement of policy would be as follows: "Whereas radiation can be instrumental in the improvement of the public health, welfare, and national productivity if properly utilized, and may, if improperly utilized, impair the health of the people and the industrial and agricultural potentialities of the State; it is hereby declared to be the public policy of this State to encourage the constructive uses of radiation, and at the same time to evaluate their effects on health and crops, and to prevent these effects from becoming harmful."

71 (b) *Definitions.* Definitions of any special or new terms, or special use of common words, are essential to the proper understanding, interpretation, and enforcement of an Act or the regulations under the Act. Practice in the matter of definition appears to vary widely. At least one set of regulations includes definitions of a large number of scientific terms that are widely used and accepted in scientific circles. It has also been noted that some of these "legal" definitions are not in agreement with accepted "scientific" definitions. Should the scientific basis of a definition become involved in a legal issue, as well it might, the State would undoubtedly be placed in a very embarrassing situation when faced with expert scientific witnesses. We can see no valid reason for including in a basic Act definitions of such terms as alpha ray, beta ray, electromagnetic radiation, electron, microcurie, etc.

72 Ordinary words should be used in their dictionary meaning; and technical words according to present usage among scientists, as set forth in the National Research Council's Glossary of Terms in Nuclear Science and Technology and in the American Standards Association's Definitions of Electrical Terms. Only terms used in a narrower sense or with special meaning need to be defined in the Act.

73 Certain definitions are essential. Such terms as board, department, establishment, hazard, minor, secretary, etc., may carry special connotation in the Act and should be unambiguously defined. Some of these terms may be differently defined and used in the Acts of the several States.

74 (c) *Scope.* The Act or Regulations should describe precisely the scope of activities. The need for such a statement has become obvious in the study of some examples in which the areas of coverage could be determined only from the text.

75 Of importance in the development of radiation control is the necessity for including all forms of radiation in the same Act. Prior to 1945 the only major forms of radiation were X-rays and the rays from radium. Since then the use of other radioactive materials has greatly complicated the protection problem—in fact it is the new sources that have led to the urge for radiation-control regulations. The inclination has been toward legislation directed primarily or solely toward the control of radioactive isotopes. It is felt that this is a mistake, as the body suffers similarly whatever the source of the radiation. To control one and not others does not make sense. There is little point in the close

regulation of a feeble source of radiation from a radioactive isotope while, at the same time, completely ignoring a chronic occupational exposure to X-rays.

76 There has been a wealth of information relative to X-ray and radium protection accumulated over many years; in fact it is this information that has provided the primary data used to determine the maximum permissible exposures for all other radiations. This experience cannot simply be put to one side, for it provides the primary basis of over-all radiation-protection principles. *It is our strong conviction that any radiation-control Act should provide coverage for all kinds of ionizing radiation regardless of source. To do otherwise is only to invite confusion and conflict.*

77 (d) *Exemptions.* We live in the presence of radiation and with radioactive substances normally in our bodies. Furthermore we regularly suffer tiny irradiations from luminous dial watches and the like, and we willingly submit ourselves to X-rays for medical purposes. Such things must be exempted from the prohibitions of the code if the control Act is not to be made ridiculous. The proposed radiation-control code of New York has set forth such exemptions very clearly.

78 (e) *Prohibitions.* The mere possession of some materials and some apparatus should be prohibited. Some uses and some methods of disposal also should be prohibited.

79 For most materials and apparatus, the use and handling should be regulated, the code specifying requirements to make the operations safe. It should be made possible for a prospective user to get an opinion in advance regarding the acceptability of safety measures planned for a proposed use of radiating materials or machines. This opinion need not be binding. Measurements during later operations may make amendments necessary, or may prove the installation acceptable even though the opinion may not have been heeded.

80 (f) *Registration.* The general philosophy of registration of uses has been discussed above. To repeat: We think that knowledge of location and nature of sources of radiation with opportunity to inspect will provide as good a foundation for control as actual licensing. We do not mean merely to substitute registration as a more palatable word than licensing. We do think registration more attainable, but it will not be so if an attempt is made to accomplish what amounts to licensing under the name of registration.

81 The mere acceptance of a registration by the control Agency must not in any way imply approval of the use. On the other hand there must be no mechanism by which a registered use can be prevented through neglect of some action by the Agency. Such stoppage should result only from inspection and disapproval.

82 The process whereby a user notifies the Agency of the existence or use of a radiation source should be fundamentally simple. Having received the notification, the Agency can then require the filing of whatever information is deemed necessary. If the questionnaire is not returned as requested, the Agency can make an inspection. It should have authority to inspect any registered use at will. It should have authority to ask court warrant to inspect for any unregistered use.

83 Questionnaires should be as simple and brief as possible for two main reasons: (1) to encourage the user to reply promptly, and (2) to minimize paper work and administration by the Agency. If the Agency finds its early forms insufficient, elaboration can follow as experience is gained. In any case, the demand for superfluous or redundant information should be avoided.

84 The user should be assured that the information he submitted has been received. The questionnaire could be filed in duplicate, the second copy stamped by the Agency and returned to the user. Or a tear tab bearing identification number could be mailed back to the user. Sending the information by registered mail with return receipt would be another suitable procedure.

85 Reregistration for changes in usage also should be made simple. To fill out a new questionnaire for every small change in amount or kind of use would be absurd. For technical reasons it appears impossible to make a legal determination of the "degree of change" that should require reregistration. For a user of I^{131} the additional use of P^{32} presumably does not increase the hazard; but use of Sr^{90} presumably warrants review if not inspection. Categories of reportable changes should be a matter for administrative decision by the Agency, which should keep users informed of its requirements in this regard and notify them of any changes.

86 For many situations it should be possible to have a "blanket registration." It could be subsequently determined by the control Agency whether or not such broad coverage is warranted. The continuance of such registration could be made dependent upon meeting certain internal radiation-control provisions, as for example those required by the Atomic Energy Commission of its holders of blanket authorizations to procure radioactive isotopes. Covered by such blanket registration would be certain research institutions, manufacturers, etc., whose radiation conditions are undergoing constant change.

87 Also there are certain types of operation, other than those mentioned above, that should be exempt from re-registration or should come under some form of blanket registration. Included in this group might be such operations as the manufacturing and testing of radiation-producing equipment, storage of radiation-producing equipment not being operated in a manner to produce radiation, and storage and handling of devices with luminous dials (although bulk storage of these might constitute a hazard).

88 (g) *Advisory Board.* The creation and organization of the Advisory Board should be included in the basic Act. Because the Board will have technical advisory responsibilities, it is best that its duties be defined in broad terms in the basic Act. More specific description of the duties can be developed in the regulations by the Agency if deemed necessary. It must be kept in mind that overextending the duties of the Board will undoubtedly kill it off. Such an occurrence would arouse suspicion that the Agency is incompetent, or has become restive under advice found inconvenient to accept.

89 The number of Board members should be specified, and provision made for overlapping tenure. The fields of technical competence to be covered by the Board membership should be specified, at least in a broad way. This should be based on experience rather than professional category. A radiologist as such might be of little value whereas a radiologist experienced in matters of protection would be highly desirable. A manufacturer experienced in the handling of radioactive wastes would be an asset to the Board. At least one member should be a physician, and others should have had experience in waste disposal, radioactive-handling procedures, shielding design, instrumentation and measurements, body uptake and elimination of radioactivity, and the radiation injury syndrome.

90 The advisory functions of the Board should be stated in the basic Act. In addition to specifying certain duties of the Board, the language should be such as to authorize its consideration of special problems in the field of radiation hygiene that may not have been initially anticipated. Specific duties should include (1) evaluation of the over-all radiation-protection problem of the State, (2) decision as to the technical limitations to be placed on radiation sources and their use, (3) review of national protection codes or recommendations with a view to adaptation to the State's needs, (4) decision as to training programs for Agency personnel, (5) development of technical investigations when necessary to solve some special protection problem, and (6) study and development of the general rules of administrative procedure for use by the Agency. It may be desirable to have the Act specify such authority for the Board without requiring it to exercise actively all phases of the authority granted. The Act must state the intent clearly if administrative uncertainties are to be avoided. (Language in the 1946 U. S. Atomic Energy Act caused considerable confusion as to whether or not the Atomic Energy Commission was expected to promulgate radiation-protection regulations, and if so what areas they were to cover; language in the 1954 Atomic Energy Act is clear and explicit in this regard.)

91 (h) *Administration.* This section is probably the key to the entire Act, as it spells out the means by which the Act will be rendered effective. It is in this area that the greatest variations between States can be expected to occur. Only a few of the details are touched upon here.

92 A section should specify the organization and location of the control Agency, and state its relationship to the Department, Division, or Authority of which it is to be a part.

93 Provision should be made for the holding of public hearings on the establishment of the Act and of the regulations to be set forth under the Act, and on any proposed amendments to either. If the initial Act relegates specific quantitative standards to the regulations, it can be hoped that the regulations can be adapted to increasing knowledge without need to amend the Act itself.

94 The Agency should be given authority to order the user to correct deficiencies wherever inspection reveals unsafe operating conditions or violation of the established code of safe practice. A procedure should be established for appealing such administrative orders or for relief from regulations deemed too restrictive. The constitution and authority of the appeal board should be stated.

95 Penalties must be prescribed for proven violation of the Act or regulations and for failure to register. The Agency should be empowered to petition for an injunction to prevent anticipated violations. Further details regarding reviews of decisions and appeals to court would be desirable. As far as the public is concerned, their avenues of appeal and redress are as important as the basic requirements with which they have to comply.

96 Procedures of entry and inspection must be described fully. This easily can be one of the most troublesome features, legally, in any enforcement program because of the privacy of everyone's domain. The right of inspection is essential but inspection procedures should be as inoffensive as possible. A program of inspection procedures and reports should be developed and made available to the public. This should not be a part of either the basic Act or the regulations, lest the flexibility and evolutional development of the program be curtailed.

97 Records of radiation usage, personnel exposure, and radioactive-isotope acquisition and disposal should be required in many areas of operation. There will certainly be some areas where such records will serve no useful purpose and only be a burden and nuisance to the user. The decision as to the users who should keep records should not be written into the Act, but left to the discretion of the Agency.

98 Classification of radiation sources according to their potential hazard has been proposed. This may have some value as a part of the administrative procedure but should not be included in the basic Act. The use of classifications in the American Standards Association Z–54 code frequently has resulted in the construction of Class-A installations where the less costly Class-B installations would have been entirely adequate. This sort of classification can be misused by persons having special interests, by demanding or selling protection beyond that dictated by good practice or common sense.

99 On the other hand, classification may assist in providing a line of demarcation as to when certain records should be kept or reregistration be required. We believe that difficulty will be minimized by leaving classification to the discretion of the Agency.

100 The Act should contain the customary legal language designed to avoid conflict with other laws, and to preserve existing rights and remedies. Any applicable existing legislation should be adequately referenced or even repeated.

2.11. Use of New Versus Existing Legislation

101 We have emphasized the desirability of suitable basic enabling legislation as opposed to detailed technical legislation. As a matter of fact, many States already have Acts of various sorts, usually as a part of a general Labor or Health Act, under which, either directly or by some stretch of imagination, radiation-control regulation can be established. In this way radiation control may conceivably be handled under "noxious gases," "stream pollution," or some other seemingly incongruous category. In one such case the State is assumed to have power to regulate the use of radioactive isotopes (including radium) but not X-ray machines.

102 In case it is decided necessary to legislate concerning use of radiation, we believe matters ought not to be handled with this side-door approach. Radiation control deserves its own integrated Act covering all types of hazardous radiations.

The present time, when only one or two States actually have a radiation-control program in force, appears to be particularly propitious for a fresh start based on the widest sampling of expert opinion. This would go far in promoting uniformity in a field that will have powerful social and technical implications in the future. In fact, the problem is one of international import when we consider such problems as the disposal of radioactive waste at sea or the contamination of air masses that may leave our continental boundaries.

Appendix A. A Suggested State Radiation-Protection Act

"AN ACT for the Control of Radiations from Machines and Radioactive Materials, for the Purpose of Protecting Health."[2]

Short Title. This Act may be referred to as the _____ Radiation Hygiene Act.
(State)

Section 1. Statement of Policy. Whereas, radiation can be instrumental in the improvement of health, welfare, and productivity of the public if properly utilized, and may impair the health of the people and the industrial and agricultural potentials of the State if improperly utilized, it is hereby declared to be the public policy of this State to encourage the constructive uses of radiation and to control any associated harmful effects. (69–70, 75–76)[3]

Section 2. Definitions. For the purposes of this Act, the following words and phrases are defined (71–73):

(a) *Radiation* is gamma rays and X-rays, alpha and beta particles, high-speed electrons, neutrons, protons, and other nuclear particles; but not sound or radio waves, or visible, infrared, or ultraviolet light.

(b) *Radiation machine* is any device that produces radiations when the associated control devices are operated.

(c) *Radioactive material* is any material, solid, liquid, or gas, that emits radiation spontaneously.

Additional definitions may be included.

Section 3. Creation and Organization of Agency: Advisory Board, Meetings, Employees. (28–49)

(a) There is hereby created and established a State Radiation-Control Agency hereinafter referred to as the Agency. The Agency shall be an organizational component of the State Department of _____. (Alternate: There is hereby created and established an independent State Radiation-Control Agency, hereinafter referred to as the Agency.) (28–42)

(b) The Governor shall appoint a Director of the Agency (hereinafter called the Director) who shall perform and carry out all functions and duties given to the Agency under this Act, and shall direct, carry out, and enforce all radiation

[2] The title should conform to State requirements. The above is a suggestion; a more complete title should be used where necessary.

[3] Numbers in parentheses refer to background discussions in section 2.

safety control activities and measures vested in the Agency. The Director shall be a person having extensive training and experience in the field of health and of radiation protection. (15)

(c) In accordance with the laws of the State, the Agency may employ, compensate, and prescribe the powers and duties of such persons as may be necessary to carry out the provisions of this Act.[4] However, technical, legal, and other services shall be performed, insofar as practicable, by personnel of existing State departments, agencies, and offices. (39–42)

(d) The Director may delegate to officers and employees of the Agency such functions, duties, and authority as are vested in the Agency by this Act; except the authority to adopt and promulgate standards, rules, and regulations, and to issue or modify orders.

(e) There is hereby established within the Agency a State Radiation Technical Advisory Board, hereinafter referred to as the "Board," consisting of five members. (43–49, 88–90) The Director of the Agency shall be a member of the Board. The other four members shall be persons with scientific training in one or more of the following fields: health, agriculture, medicine, radiology, radiation physics, biology, industry, labor, atomic energy. The Governor shall appoint these four members after seeking recommendations of established authorities or organizations in the above-specified fields. (89) The members' term of office shall be four years, except that the terms of those first appointed shall expire as follows:

1 at the end of 1 year after such date,
1 at the end of 2 years after such date,
1 at the end of 3 years after such date, and
1 at the end of 4 years after such date

as designated by the Governor at the time of appointment. If a vacancy occurs, the Governor shall appoint a member for the remaining portion of that term. The Director of the Agency shall be Chairman of the Board. The Board shall hold four regular meetings each calendar year, and special meetings as deemed necessary by the Board or the Director. It shall be the duty of the Board to review the policies and program of the Agency as developed under authority of this Act; to make recommendations thereon to the Agency; to provide the Agency with such technical

[4] It may be necessary to include a statutory provision for the salary of the Director of the Agency, if State statutes do not provide an over-all compensation system for State officials.

advice and assistance as may be required relative to permissible exposure levels, standards of practice, radiation instrumentation, and other technical matters. (90) Members of the Board, other than the Director, shall be entitled to receive compensation at _____ dollars per diem and reimbursement for actual and necessary traveling and subsistence expenses while engaged in the business of the Board.

Section 4. Powers and Duties of the Agency. The Agency shall have the following powers and duties:

(a) Shall develop comprehensive policies and programs for the evaluation and determination of hazards associated with the use of radiation, and for their amelioration;

(b) Shall advise, consult, and cooperate with other agencies of the State, the Federal Government, other States and interstate agencies, and with affected groups, political subdivisions, and industries in furtherance of the purposes of this Act;

(c) May accept and administer loans, grants, or other funds or gifts from the Federal Government and from other sources, public or private, for carrying out any of its functions; (22)

(d) May encourage, participate in, or conduct studies, investigations, training, research, and demonstrations relating to the control of radiation hazard, the measurement of radiation, the effects on health of exposure to radiation, and related problems as it may deem necessary or advisable for the discharge of its duties under this Act;

(e) Shall collect and disseminate information relating to the determination and control of radiation exposure and hazard;

(f) Shall adopt and promulgate such rules and regulations as may be necessary to further the purposes of this Act; such rules and regulations may incorporate by reference the recommended standards of nationally recognized bodies in the field of radiation protection such as the National Committee on Radiation Protection or the American Standards Association; (51)

(g) Shall devise, modify, repeal, promulgate, and enforce rules and regulations as necessary to implement or effectuate the powers and duties of the Agency under this Act;

(h) May issue, modify, or revoke orders prohibiting or abating the discharge of radioactive material or waste into the ground, air, or waters of the State in accordance with the provisions of this Act and rules and regulations adopted thereunder;

(i) Upon request, shall render opinion concerning such plans and specifications on the design and shielding for radiation sources as may be submitted before or after construction, for the purpose of determining the possible radiation hazard;

(j) May make inspections of radiation sources, shielding, and immediate surroundings for the determination of any possible radiation hazard; and shall provide the owner, user, or operator thereof with a report of any known or suspected deficiencies;

(k) May exercise all incidental powers necessary to carry out the purposes of this Act.

Section 5. Registration.

(a) It shall be unlawful for any person to produce radiation, or to produce, use, store, or dispose of radioactive materials, or to modify, extend, or alter such activities, unless he registers in writing with the Agency in accordance with the procedures prescribed by such Agency, except that a period of 90 calendar days shall be allowed for such registration after the effective date of this Act. (80–87)

(b) It shall be unlawful for any person to produce radiation, or to produce, use, store, or dispose of radioactive materials, except in accordance with the provisions of this Act and rules and regulations promulgated thereunder. (78–79)

Section 6. Classification of Sources and Hazards and Standards of Protection. (28, 98–99)

(a) The Agency is authorized, with the concurrence of the Board, to classify radiation sources, exposures, and hazards for the purpose of (1) making inspections, (2) determining the competence of the radiation users, (3) determining the adequacy of radiation-protective devices and procedures, and (4) other purposes compatible with the present and future utilization of all forms of radiation, taking into account the protection of the health of the people of this State.

(b) Prior to the establishment of a system of classification of sources or uses, or setting standards of protection, or modifying such classifications or standards, the Agency shall conduct public hearings in connection therewith. Notice shall be given of time, date, and place of public hearing and shall specify the technical area in which a classification is sought to be made or for which standards are sought to be adopted. Such notice shall be published at least twice in a newspaper of general circulation in the area affected, and shall be mailed at least 20 days before such public hearing to the chief executive of each political subdivision of the geographical area

affected, and may be mailed to such other persons as the Agency has reason to believe may be affected by such classification and the setting of such standards. The Agency shall utilize the assistance of the Board in connection with such hearings.

(c) The adoption of standards of protection and the classification of radiation sources, or any modification or change thereof, shall, upon approval of the Board, be issued as an order of the Agency and shall be published in a newspaper of general circulation in the area affected. In classifying sources and setting radiation-protection standards, or making any modification thereof, the Agency shall permit and announce a reasonable time for the persons or users involved to comply with such classification and standards, if their operations create a known hazard to health; except that a user may be directed to abate without delay a serious known hazard to health.

Section 7. Examination for Compliance: Statement of Noncompliance.

(a) The Agency shall itself, or by its duly designated representatives, inspect and examine such sources of radiation as it desires, in order to determine their compliance with the adopted classification and radiation-protection standards of the Agency.

(b) If such inspection and examination indicates that the source of radiation is not in compliance with the adopted classification and radiation-protection standards, the owner, operator, or user shall be so notified in writing, with full particulars regarding any deficiencies.

Section 8. Proceedings before Board.

(a) Whenever the Agency determines there are reasonable grounds to believe that there has been a violation of any of the provisions of this Act or of any order of the Agency, it may give written notice to the alleged violator or violators specifying the causes of complaint. Such notice shall require that the alleged violations be corrected or that the alleged violator appear before the Agency at a time and place specified in the notice, and answer the charges. The notice shall be delivered to the alleged violator or violators in accordance with the provisions of subsection (d) of this section not less than _____. days before the time set for the hearing.

(b) The Agency shall afford the alleged violator or violators an opportunity for a fair hearing in accordance with the provisions of section 9 at the time and place specified in the notice or any modification thereof. On the basis of the evidence produced at the hearing the Agency shall make findings of fact and conclusions of law and enter such order as in its opinion will best further the purposes of this Act and shall give written notice of such order to the alleged violator and to such other persons as shall have appeared at the hearing and made written request for notice of the order. If the hearing is held before any person other than the Agency itself, such person shall transmit the record of the hearing together with recommendations for findings of fact and conclusions of law to the Agency, which shall thereupon enter its order on the basis of such record and recommendations. The order of the Agency shall become final and binding on all parties unless appealed to the courts as provided in section 12 within _____ days after notice has been sent to the parties.

(c) Whenever the Agency finds that an emergency exists requiring immediate action to protect the public health or welfare, it may, without notice or hearing, issue an order reciting the existence of such an emergency and requiring that such action be taken as it deems necessary to meet the emergency. Notwithstanding the provisions of subsection (b) of this section, such order shall be effective immediately. Any person to whom such order is directed shall comply therewith immediately, but on application to the Agency shall be afforded a hearing as soon as possible. On the basis of such hearing the Agency shall continue such order in effect, revoke it, or modify it.

(d) Except as otherwise expressly provided, any notice, order, or other instrument issued by or under authority of the Agency may be served, personally or by publication, on any person affected thereby, and proof of such service may be made in like manner as in case of service of a summons in a civil action, such proof to be filed in the office of the Agency; or such service may be made by mailing a copy of the notice, order, or other instrument by registered mail, directed to the person affected at his last known post office address as shown by the files or records of the Agency, and proof of such service may be made by the affidavit of the person who did the mailing, such proof to be filed in the office of the Agency.

(e) Every certificate or affidavit of service made and filed as herein provided shall be *prima facie* evidence of the facts therein stated, and a certified copy thereof shall have like force and effect.

Section 9. Hearings. The hearings herein provided may be conducted by the Director, or the Director may designate hearing officers who shall have the power and authority to conduct such hearings in the name of the Agency, at any time and place. A record or summary of the proceedings of such hearings shall be made and filed with the Agency, together with findings of fact and conclusions of law made by the Agency. A member of the Agency or a hearing officer, designated by the Agency, shall have the power to issue in the name of the Agency notice of the hearings or subpoenas requiring the testimony of witnesses and the production of evidence relevant to any matter involved in such hearing, and to administer oaths and examine witnesses during such hearings. Witnesses who are subpoenaed shall receive the same fees and mileage as in civil actions. In case of contumacy or refusal to obey a notice of hearing or subpoena issued under this section, the ---------- Court shall have jurisdiction, upon application of the Agency or its representative, to issue an order requiring such person to appear and testify or produce evidence as the case may require, and any failure to obey such order of the court may be punished by such court as contempt thereof.

Section 10. Inspections and Investigations: Maintenance of Records. The Agency or its duly authorized representative shall have the power to enter at reasonable times, and after prior notice of at least 2 days, upon any private or public property for the purpose of inspecting and investigating conditions relative to the purposes of this Act; except that such entry into security areas under the direct or indirect jurisdiction of the Federal Government shall be permitted only by and with the concurrence of the Federal Government Agency or its duly designated representative. (96)

Any authorized representative of the Agency may examine any records or memoranda pertaining to the operation of radiation machines and radioactive materials. The Agency may require the maintenance of records relating to the operation of disposal systems. Copies of such records must be submitted to the Agency on request. (97)

Section 11. Penalties: Injunctions. (95)

(a) Any person who violates any of the provisions of, or who fails to perform any duty imposed by, this Act, or who violates any order of the Agency promulgated pursuant to

this Act, shall be guilty of a misdemeanor, and in addition thereto may be enjoined from continuing such violation. Each day upon which such violation occurs shall constitute a separate violation.

(b) It shall be the duty of the Attorney General on the request of the Agency to bring any action for an injunction against any person violating the provisions of this Act, or violating any order of the Agency. In any action for an injunction brought pursuant to this section, any findings of the Agency after hearing or due notice shall be *prima facie* evidence of the fact or facts found therein.

Section 12. Review. (95)

(a) An appeal may be taken from any final order, or other final determination of the Agency, by any person who believes himself adversely affected thereby, or by the Attorney General on behalf of the State of the ---------- Court of the State in the area affected or to the ---------- Court of ----------.
(Seat of Government)

Within 30 days after receipt of a copy of the order, or other determination, or after service of notice thereof by registered mail, the appellant or his attorney shall serve a notice of appeal on the Agency through its (Director) provided that during such 30-day period the court may, for good cause shown, extend such time for an additional period not to exceed 60 days. The notice of appeal shall refer to the action of the Agency appealed from, shall specify the grounds of appeal, including both points of law and fact which are asserted or questioned by the appellant. A copy of the original notice of appeal with proof of service shall be filed by the appellant or his attorney with the clerk of the court within 10 days of the service of the notice and thereupon the court shall have jurisdiction of the appeal.

(b) The appellant and the Agency shall in all cases be deemed the original parties to an appeal. The State, through the Attorney General or any other person affected, may become a party by intervention, as in a civil action, upon showing cause therefor. The Attorney General shall represent the Agency, if requested, upon all such appeals unless he appeals or intervenes in behalf of the State. If the Attorney General or a member of his staff is not available to represent the Agency in any particular proceeding, the Agency is empowered to appoint special counsel for such proceeding. No bond or deposit for costs shall be required of the State or Agency upon any such appeal or upon any

subsequent appeal to the Supreme Court or other court proceedings pertaining to the matter.

(c) The appeal shall be heard and determined by the court upon the issues raised by the notice of appeal and the answer thereto according to the rules relating to a trial in the nature of an appeal in equity of an administrative determination. All findings of fact by the Agency are to be deemed final, unless it is shown that such findings were not supported by substantial evidence produced before the Agency at the hearing. In any appeal or other proceeding involving any order, or other determination of the Agency, the action of the Agency shall be *prima facie* evidence reasonable and valid and it shall be presumed that all requirements of the law pertaining to the taking thereof have been complied with. A copy of the proceedings before the Agency shall be certified to the court in connection with each appeal.

(d) A further appeal may be taken to the Supreme Court of the State in the same manner as appeals in equity are taken.

Section 13. Conflicting Laws. This Act shall not be construed as repealing any laws of the State relating to radiation sources, exposures, radiation protection, and professional licensure, but shall be held and construed as auxiliary and supplementary thereto, except to the extent that the same are in direct conflict herewith. (100)

Section 14. Existing Rights and Remedies Preserved. It is the purpose of this Act to provide additional and cumulative remedies to evaluate, control, and prevent impairment to health from radiation and to encourage the constructive use of radioactive materials and radiation machines. Nothing herein contained shall be construed to abridge or alter rights of action or remedies in equity or under the common law or statutory law, criminal or civil, nor shall any provision of this Act, or any act done by virtue thereof, be construed as estopping the State, or any municipality or person, in the exercise of their rights in equity or under the common law or statutory law to protect the public health and encourage commerce and industry. (100)

Section 15. Severability. If any section, subsection, sentence, clause, phrase, or word of this Act is for any reason held to be unconstitutional, such decree shall not affect the validity of any remaining portion of this Act.

Appendix B. Suggested Regulations

PREAMBLE

(Not a part of the regulations)

a. The main endeavor of these regulations is to incorporate the basic technical principles that should be applied uniformly between this and other States.

b. These regulations are based on present knowledge of radiation and its biologic effects; with further research, this information can be expected to improve. The Agency will publish from time to time such new information as it deems pertinent, giving references to the sources of new data.

c. Although the values proposed for maximum permissible dose are such as to involve a risk that is small compared to the other hazards of life; nevertheless in view of the unsatisfactory nature of much of the evidence on which our judgments must be based, coupled with the probability that certain radiation effects are irreversible and cumulative, *it is strongly recommended that every effort be made to reduce the dose of all types of ionizing radiations to the lowest practicable level.*

d. Because it is not possible to predict the period of time over which an individual may be occupationally exposed to radiation, it is assumed that he will be so exposed at more or less a uniform average rate over his entire adult lifetime. Occasional exposure rates higher than those specified cannot be justified by assuming lower future exposures because of the arbitrary limitation that would be placed on a person's future freedom of action. (See sections 7 and 15 of these regulations.)

e. The maximum permissible dose for an individual shall be considered to include all doses from all types and energies of radiation, whether delivered simultaneously or successively, during the period of measurement to the region of interest.

f. The requirements specified in these regulations are consistent with the recommendations of the National Committee on Radiation Protection.

g. More detailed information on maximum permissible exposure can be obtained from National Bureau of Standards Handbook 59, "Permissible Dose from External Sources of Ionizing Radiation," and Handbook 52, "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water."

1. Scope

It is the purpose of these regulations to state such requirements as shall be applied in the use of all radiation, radiation machines, and radioactive materials to insure the maximum safety to all persons at, or in the vicinity of, the place of use, storage, or disposal thereof. These regulations are intended to be consistent with the best use of radiation machines and radioactive materials. (74–76)

2. Application

a. All radiation machines and radioactive materials shall be manufactured, used, stored, handled, transported, or disposed of in such manner that no person shall receive an excessive radiation dose therefrom. Except as exempted by the provisions of section 4 of these regulations, the manufacture, use, storage, handling, transportation, or disposal of radiation machines and radioactive materials shall be subject to the specific regulations provided below.

b. For the purposes of these regulations, radiation machines and radioactive materials used by, or in the possession of, an employee within the scope of his duties shall be considered to be in the possession of the employer.

3. Definitions

For the purposes of these regulations the following definitions shall apply: (71–73)

Absorbed dose of any radiation is the amount of energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest.

Adult is a person of age 18 or more. This age limitation is for radiation-protection purposes only and bears no relationship to age limits for social, political, or other legal considerations.[5]

Agency is that governmental agency that is given the responsibility for administering these regulations.

Body burden is the amount of radioactive material in the body at the time of interest.[6]

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[5] Section 6, National Bureau of Standards Handbook 59.
[6] Section D, National Bureau of Standards Handbook 52.

Critical organ is that part of the body that is most susceptible to radiation damage under the specific conditions considered.

Excessive radiation dose is a dose of radiation in excess of the maximum permissible dose. (Depending upon the degree of excess, these conditions represent serious hazard only when they are maintained or repeated frequently over long periods of time.)

Harmful effect is any body injury, disease, or impairment, except where such condition is transitory, infrequent, or of short duration, and does not endanger persons so affected.

Installation is the area of radiation hazard under the administrative control of the person or organization possessing the source of radiation.

Maximum permissible dose is a dose of radiation that, in the light of present knowledge, is not expected to cause appreciable bodily injury to a person at any time during his lifetime.[7]

Personnel monitoring is the determination of the radiation dose received by a person during a specified period.[8]

Population group is a civil population (usually more than 100,000 persons) living in geographic proximity and generally dependent upon the same sources of food and water.

Qualified expert is a person fitted by training and experience to perform dependable radiation surveys, to oversee radiation monitoring, and to estimate the degree of radiation hazard. If the ability of a qualified expert is questioned, the Agency shall be the judge of his qualifications, in regard to which it may consider the testimony of other persons whom it deems expert.

Rad is the unit of absorbed dose and is equal to 100 ergs per gram. It is a measure of the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest.[9]

Radiation is gamma rays and X-rays, alpha and beta particles, high-speed electrons, neutrons, protons, and other nuclear particles; but not sound or radio waves, or visible, infrared, or ultraviolet light.

Radiation hazard is any condition that might result in the exposure of persons to radiation in excess of the maximum permissible dose.

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[7] Section 4.3, National Bureau of Standards Handbook 59.
[8] National Bureau of Standards Handbook 51.
[9] International Commission on Radiological Units (1953). See Am. J. Roentgenol. Radium Therapy Nuclear Med. **71,** 139 (1954); Radiology **62,** 106 (1954).

Radiation machine is any device that produces radiation when the associated control devices are operated.

Radioactive material is any material, solid, liquid, or gas, that emits radiation spontaneously.

Relative Biological Effectiveness (RBE) is the biological effectiveness of one type and energy of radiation, relative to that of lightly filtered X-rays generated at potentials of 200 to 300 kilovolts, for the particular biological system and biological effect, and for the conditions under which the radiation is received.[10]

Rem is the quantity of any 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 from lightly filtered X-rays generated at potentials of 200 to 300 kilovolts. A dose in rems is equal to the dose in rads multiplied by the appropriate RBE.[11]

Sealed source is a quantity of radioactive material so enclosed as to prevent the escape of any radioactive material, but at the same time permitting radiation to come out for use.[12]

Survey is the evaluation of radiation near a source by, or under the supervision of, a qualified expert.[13]

Other scientific and technical terms not herein specifically defined shall be used in accordance with the definitions in (1) recommendations of the National Committee on Radiation Protection as published in Handbooks of the National Bureau of Standards, or (2) National Research Council Glossary of Terms in Nuclear Science and Technology,[14] with preference being in the order given above.

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[10] Section 3.6, National Bureau of Standards Handbook 59.
[11] Section 4.8, National Bureau of Standards Handbook 59.
[12] National Bureau of Standards Handbook 54.
[13] National Bureau of Standards Handbook 51.
[14] Published by American Society of Mechanical Engineers, 29 West 39th Street, New York City, New York, 1953.

4. Exemptions

a. These regulations shall not apply to the following materials, machines, or conditions: (77)

(1) Natural radioactive materials of an equivalent specific radioactivity not exceeding that of natural potassium.

(2) Radioactive material in such quantity that if the entire amount were taken internally, continuously, or at one time by a person, no harmful effect would be likely to result. Listings of the upper limits of quantities of radioactive materials that shall be exempt from these regulations and from registration are given in section 15.c and table 1 of these regulations. These limits apply only for radioactive material not contained in sealed sources.

(3) Radioactive materials in sealed sources in total quantities not exceeding 1 millicurie for a given installation.

(4) Timepieces, instruments, novelties, or devices containing self-luminous elements, except during manufacture or repair of the self-luminous elements themselves.

(5) Electrical equipment that is primarily not intended to produce radiation and that, by nature of design, does not produce radiation at the point of nearest approach at a weekly rate higher than one-tenth (1/10) the appropriate permissible dose for any critical organ exposed. The production testing or production servicing of such equipment shall not be exempt.

(6) Radiation machines not being used in such manner as to produce radiation.

(7) Any radioactive material being transported on vessels, aircraft, railroad cars, or motor vehicles in conformity with the regulations adopted by any agency having jurisdiction over safety during transportation.

(8) The Agency may exempt radiation machines or radioactive materials known to be without hazard, and shall authorize the labeling of the ones that it does exempt.

b. Nothing in these regulations shall be construed to limit the kind and amount of radiation that may be intentionally applied to a person for diagnostic or therapeutic purposes by, or under the direction of, a physician or dentist.

c. (Applications for exemptions to conform to general State practices.)

5. Standards

Recommendations of the National Committee on Radiation Protection as published in Handbooks of the National Bureau of Standards shall be used as guides or standards or as a basis for calculations to obtain or maintain safe working conditions within the meaning of the regulations herein, but shall not be considered in whole or in part as a portion of these regulations unless specifically so stated.* (55)

*Alternate: Recommendations of the National Committee on Radiation Protection as published in National Bureau of Standards Handbooks 42, 48, 49, 51, 52, 53, 54, 55, 56, 58, 59, and 60 shall be used as guides or standards or as a basis for calculations to obtain or maintain safe working conditions within the meaning of the regulations herein. (If this Alternate is used, appropriate parts of sections 3, 7, and 15 of these regulations may be omitted.)

6. Registration

a. Any person using or operating any radiation machine, or storing, manufacturing, using, or handling any radioactive material, shall notify the Agency of the fact in writing within 30 days following the commencement thereof. Said notice shall state the location, nature, and scope of such operation, use, or storage, and shall be reviewed and if necessary brought up to date annually thereafter.

b. The notification in paragraph (a) above shall include an estimate of any further accession of radiation machines or radioactive material expected during the ensuing year. Any accession in excess of the estimate shall be registered promptly.

c. Acknowledgment of registration shall not imply the approval by the Agency of the manufacture, storage, use, or operation described in the registration, but shall merely indicate that the Agency has a record of the locations and establishments where radiations are used. (80–87)

7. Maximum Permissible Dose

a. The exposure of persons to radiation shall always be kept to the lowest practicable level.

b. When the source of radiation is outside the body, the maximum permissible dose rate shall not exceed those values specified in section 15.d and table 2 of these regulations.[15]

c. Quantities of radioactive material on the surface of the body, or on clothing worn by the person, shall not exceed those that will result in average dose rates to any portion of the body greater than the applicable permissible value specified in section 15.d and table 2 of these regulations.

[15] National Bureau of Standards Handbook 59.

(The skin will generally be the critical organ for sufficiently small sources of radiation. For such cases, the area over which the dose is averaged shall be of the order of 1 square centimeter.) Wounds, cuts, or abrasions of the skin involving contamination shall be given immediate medical attention for the removal of such contamination.[16]

d. The maximum permissible dose for an individual shall be considered to include all doses, from internal and external sources, from all types and energies of radiation, whether delivered simultaneously or successively, to the region of interest, during the period of measurement.

e. Radiation dose to the tissues of the body from radioactive materials within the body shall be controlled by limiting the average rates at which radioactive materials are taken into the body either by inhalation or by ingestion. Where such intake results from the occurrence of a radioisotope in air or water, the average concentration of the radioisotope in the air or water used by the individual shall not exceed the maximum permissible concentration specified in table 5 of these regulations.[17]

f. The determination of the dose received by persons and degree of hazard present in all places to which these regulations apply shall be guided by nationally recognized standards such as (1) the recommendations of the National Committee on Radiation Protection as published in Handbooks of the National Bureau of Standards, and (2) Safety Standards of the American Standards Association.

g. The radiation dose to any population group shall be limited to one-tenth (1/10) the maximum permissible amounts stated in section 15 of these regulations.[18]

8. Personnel Monitoring: Area Radiation Surveys

a. All accessible areas in the vicinity of radiation-producing sources shall be surveyed by, or under the direction of, a qualified expert using suitable instruments and methods for measuring radiation, to determine the maximum levels of radiation to which persons may be exposed. For protection purposes these measurements shall be reduced to weekly doses taking into consideration the amount of time the radiation is being produced, the work week, and the fraction of the week that any person might be exposed to the radiation.

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[16] National Bureau of Standards Handbook 48.
[17] National Bureau of Standards Handbook 52.
[18] International Commission on Radiological Protection (1953), Brit. J. Radiol. Suppl. No. 6 (1955).

b. In lieu of an actual survey a written statement made by a qualified expert based on his analysis of the situation shall be acceptable as evidence of the absence of radiation hazard in a given area.

c. Personnel monitoring shall be required for each individual for whom there is any reasonable possibility of receiving a weekly dose of all radiations exceeding one-quarter (1/4) of the maximum permissible amounts specified in sections 7.b through 7.f of these regulations taking into consideration the use of protective gloves, aprons, or other radiation-limiting devices; except that, continuation of personnel monitoring shall not be required if the average dose over a period of 8 weeks proves to be less than one-half (1/2) the maximum permissible amounts specified in sections 7.b through 7.f of these regulations. If the specified operating conditions are changed, a new monitoring test over an 8-week period shall be made.

d. Routine monitoring of persons occupationally exposed to radiation from radiation machines shall not be required when all of the following conditions are met:

(1) A qualified expert has specified the operating conditions under which there is no reasonable chance that any person will be exposed to more than one-quarter (1/4) the maximum permissible dose.

(2) The operating conditions in (1) above are made known to all persons who may be occupationally exposed to the radiation.

(3) The installation continues to operate only under the specified conditions.

e. Regularly scheduled monitoring of the air within the installation for radiation or radioactive content shall be required when there is any reasonable possibility that the average levels of activity therein may exceed one-quarter (1/4) the amount specified in table 5 of these regulations. Measurements averaged over a maximum period of 13 weeks shall be permissible, but in any case there shall be sufficient monitoring to insure that no radiation hazard exists. (56–61)

9. Radiation-Exposure Records and Reports

a. Records of all measurements required under section 8 above shall be kept available for inspection by the Agency or its representative upon demand.[19] Personnel-monitoring

[19] A State may wish to specify further the length of time that such records should be kept. It is suggested that this be for the lifetime of the individual plus 2 years, or until he will have reached 70 years of age.

records shall include the Social Security numbers of the workers concerned as an aid in keeping track of an individual's total exposure.

b. Records of the amount, kind, and disposition of radioactive materials purposefully removed from the installation shall be maintained and available for inspection by the Agency or its representative upon demand.

c. Upon termination of employment of a person, the Agency shall, upon request, be supplied with a summary statement of that person's average radiation dose. (The estimated maximum dose shall be stated if no personnel monitoring has been carried out.) This record shall include statements of any circumstances wherein the dose to the employee, from any source of radiation, exceeded those specified in these regulations.[20] (97)

d. When it is known or believed that an accidental dose to a person in the installation may have exceeded 5 times the amount permitted by applicable portions of sections 7.b through 7.f of these regulations, all facts relative to the occurrence shall be reported in detail to the Agency within 7 days of the discovery thereof, and a copy of the report shall be put in that person's personnel file. The cause of the overexposure shall immediately be sought out and corrected.

10. Responsibility

a. All work performed in an installation where radiation may be present shall be under the direction of a person responsible for the radiation safety therein. His name shall be reported to the Agency.

b. The person in charge of the radiation safety in an installation shall have the following responsibilities:

(1) He shall inform himself of the hazards attendant upon the presence of radiation in the installation and, if necessary to this end, obtain the services of a qualified expert.

(2) He shall provide, or cause to be provided, any necessary instruction concerning the attendant radiation hazards and safe working practices, to all employees whose duties necessitate the handling of radioactive material or the operation of any machines that produce radiation in amount that leads to hazard, and to all other employees who are not regularly employed at such work but who may occasionally be exposed to radiation.

[20] The purpose of this requirement is to establish a central point for the maintenance of radiation-exposure records.

(3) He shall insure beyond reasonable doubt that all persons working with radiation machines or radioactive materials, and all authorized visitors to areas where radiation may be present, are properly and adequately instructed in the use of all necessary safeguards and procedures, and are supplied with such auxiliary devices as may be necessary for safety.

(4) He shall insure beyond reasonable doubt that no radioactive material (including that in patients, animals, and equipment) is allowed to leave the jurisdiction of the radiation user under circumstances that may subject other persons to radiation in amounts in excess of those indicated in sections 7.b through 7.f of these regulations.

(5) He shall insure beyond reasonable doubt that any area, inside or outside the installation, normally occupied by adults not primarily engaged in radiation or associated work, cannot be subjected to radiation levels exceeding the maximum permissible amounts indicated in sections 7.b through 7.f of these regulations.

(6) He shall insure beyond reasonable doubt that any area, inside or outside the installation, that may be habitually occupied by persons under 45 years of age and not engaged in radiation work, cannot be subjected to radiation levels exceeding one-tenth (1/10) the maximum permissible amounts indicated in sections 7.b through 7.f of these regulations, except that such exposure may be averaged over 1 year. Normal occupational exposures of pregnant women should be considered as acceptable risks.

(7) He shall notify the building superintendent or other appropriate official of the existence of any areas not normally occupied but in which hazardous radiation exposure may take place; e. g., an air-conditioning equipment room beneath X-ray installation.

(8) He shall notify the building superintendent or other appropriate official of the existence of any conditions or situations that, while not normally considered a radiation hazard, may become a hazard under special or unusual circumstances; e. g., entrapment of waste in a drainage line.

(9) He shall, by means of appropriate surveying or monitoring procedures, insure that radioactivity discharged to the atmosphere, at any point where persons may breathe the air, shall be maintained at an average concentration of radioactivity below the maximum permissible levels indicated in section 7 of these regulations.

c. Every employee and authorized visitor shall be responsible for using such safety devices as are furnished for his protection and for carrying out all radiation-safety rules that concern or affect his conduct.

11. Storage of Radioactive Materials

a. Radioactive materials shall be stored or kept in such a manner as to insure that the dose rate therefrom shall not exceed the appropriate limits specified in section 7 of these regulations.

b. Vaults or rooms in which radioactive materials are stored shall be so located and/or constructed that no person shall be exposed to radiation therefrom in excess of the appropriate limits set forth in sections 7.b through 7.f of these regulations.

c. Radioactive materials in a workroom or other location where persons are regularly or frequently present shall be enclosed in containers of such thickness, material, and construction, or otherwise shielded in such manner, that no person will be exposed to radiation in amounts greater than those indicated in sections 7.b through 7.f of these regulations.

d. Vaults or rooms used for storing materials that may emit radioactive gases shall be suitably ventilated in such a manner that the gases do not constitute a radiation hazard.

e. When there is any possibility that chemical, radiation, or other action might weaken or rupture the container of radioactive material sufficiently to cause leakage therefrom, the container shall be provided with a suitable secondary tray or catchment adequate to retain the entire amount of radioactive material.

f. Each container of radioactive material in storage shall, in addition to the standard radiation-hazard symbol (see section 13.c of these regulations), be labeled in such manner that the kind and quantity of material, the date of measurement, and the name of the person responsible for the material can be easily and quickly determined.

g. Storage containers for radioactive material in excess of 1 curie shall be designed to be resistant to fire and earthquake damage, and to maintain reasonable temperatures. Containers shall be structurally sound over the period of intended use with due regard to corrosion, radiation, and temperature effects that may develop.

h. Suitable provision shall be made to minimize the hazard to emergency workers in the event of fire and in situations where earthquake, flood, and windstorm potentials exist.

12. Radioactive-Contamination Control

a. All work with radioactive materials shall be carried out under such conditions as to minimize the possibility of any contamination that would result in any person's being subjected to radiation levels exceeding those specified in section 7 of these regulations.

b. Where the nature of the work is such that a person or his clothing may become contaminated to such degree as to present a hazard, both shall be suitably monitored. Any contamination leading to doses in excess of the values specified in section 7 of these regulations shall be removed from the contaminated person before that person is permitted to leave the work area. Clothing or other material having contamination in excess of the amounts indicated in section 7 of these regulations shall not be taken from the work area or released to public laundries or cleaners.

c. Under conditions in which the Agency considers it advisable it may devise or approve a suitable pattern of work rules applicable to individual users. These may vary from one user to another.

d. Every person using radioactive materials not enclosed in a sealed source shall have on hand or immediately available an instrument or instruments suitable for detecting and measuring contamination in accordance with the requirements of this section. These instruments shall be maintained in proper calibration. Under special circumstances, the Agency may require the same or similar instrumentation for users of radioactive materials in sealed sources.

e. Any accidental release of radioactive material beyond the control or jurisdiction of the installation shall be reported to the Agency immediately.

13. Radiation Information Labeling

a. All radiation machines shall be clearly labeled as follows:

"CAUTION—X-RAYS

This equipment produces X-rays when energized."

(Labels as required under the Federal Food, Drug, and Cosmetic Act may be substituted for the above label.)

b. All radioactive material not in process or in possession of the user shall be clearly labeled as follows:

(1) Containers for sealed sources of external hazard only:

"CAUTION—RADIATION"

(Where a time limit is specified, it should be posted.)

(2) Radioactive material in loose bulk or unsealed containers—internal hazards primarily:

"DANGER—RADIOACTIVE MATERIAL

The material contained herein should not be allowed to enter the body either by inhalation, ingestion, or through wounds in the skin."

(Labels as required under the Atomic Energy Act may be substituted, where appropriate, for the above labels.)

c. The standard symbol for designating *any* radiation hazard shall be:

The standard color specification shall be a background of yellow with lettering and distinctive symbol in purple (magenta). The use of this symbol for any other purpose is expressly prohibited. The symbol and lettering shall be as large as practical, consistent with size of the equipment or material.

d. All radioactivity containers, storage areas, work areas, or other normally occupied areas where a radiation hazard may exist shall be posted with accepted radiation-hazard labels, except where such labels may be a source of disturbance to patients undergoing radiation treatment.

e. Any areas where a radiation hazard may exist on a frequent or infrequent basis, but which are not readily accessible and are so situated as to be occupied only under infrequent and special circumstances, shall be posted with accepted radiation-hazard labels.

f. All areas that are readily accessible but not normally occupied, and where a radiation hazard may exist on a frequent or infrequent basis, shall be suitably fenced off and posted with the accepted radiation-hazard label.

g. All radiation-hazard labels posted when a radiation hazard existed shall be removed when the hazard is no longer present.

14. Disposal of Radioactive Wastes

(*Note:* It is impractical or impossible at the present time to formulate detailed waste-disposal regulations that will provide adequate safety under all conditions without being unnecessarily restrictive under most conditions. Not only do the relevant factors vary with each locality, but virtually every radioisotope presents a different problem. A few broad rules applicable to cases of most common interest can be stated, but in general the procedures must be adjusted, in the light of the general guides specified in section 7 of these regulations, to take into account the particular circumstances involved.

The disposal of radioactive waste, by the nature of the problem, develops situations different from those encountered in the normal handling of radioactive material under controlled conditions. Once a disposal event has taken place all further control over the material usually is completely out of the hands of the disposer; an irreversible train of events will have begun. It is therefore essential that special care and consideration be exercised before any disposal operation is commenced.)

a. Users of radioactive materials shall release these materials only in such manner that the radioactive material discharged, in combination with that discharged by other users, will not cause contamination of the environment that may result in a person or persons receiving an excessive radiation dose. If several users are discharging radioactive wastes to the same environment, they shall, upon being notified of the fact, cooperate in limiting the release and shall file with the Agency a statement of their agreed pro-rata releases. If this is not done within a reasonable time the Agency arbitrarily may assign quotas to them severally.

b. Users who release radioactive material may take reasonable advantage of the environmental factors (dilution, dispersion, etc.) to minimize the cost of disposal, provided they meet the performance requirements indicated in paragraph (a) above. Nothing in these regulations shall be construed as permitting release of materials that would be unlawful for other reasons.

c. Prior to and during design and construction of facilities for the handling and disposal of radioactive wastes, users of radioactive materials may obtain opinions from the Agency regarding the probability of meeting these regulations. However, the user shall remain responsible for meeting the performance standards related to radioactivity established by the Agency and shall allow representatives of the Agency to inspect and evaluate his methods of treatment and release.

d. For purposes of protection of *population groups*, the limits of radioactivity resulting from disposal of radioactive material shall be determined on the following basis:

(1) The average concentration of that isotope in air at points where it is commonly used by humans or in water at points of supply (exclusive of treatment, if any) prior to use by humans shall not exceed ten percent (10%) of the maximum permissible levels recommended in table 5, section 15 of these regulations. Concentrations lasting only over a period of a few days may be allowed to exceed the values given in table 5, provided the average concentration over any interval of one year does not exceed ten percent (10%) of these values.

(2) Average rates of radiation dose to persons from radioisotopes outside their bodies shall not exceed ten percent (10%) of the values specified in Rules I through IV, section 15.d of these regulations.

(3) Average concentrations in portions of public waterways not used as sources for human consumption shall be consistent with health, economic, and recreational uses of the water and the future plans for its use that are under consideration by responsible authorities.

(4) For any radioisotope where the effective half-life in the body is less than 60 days, the term "average" as used above shall mean the arithmetic mean of a series of determinations representative of plant operations and environmental conditions over any period of 13 consecutive weeks; for other radioisotopes this arithmetic mean shall be taken over a period of any 12 consecutive months.

(5) If the permissible average concentration of a mixture of radioisotopes in air or water depends almost entirely on the concentration of one of the radioisotopes involved, for routine practical estimates the contributions of the other radioisotopes in the mixture may be neglected. Where more than one isotope is important, the permissible concentration shall be arrived at by adding the exposures to be received from each significant component.[21]

[21] Page 42, appendix A, National Bureau of Standards Handbook 52.

e. Radioactive wastes may be disposed of by dumping or burial only in areas approved by the Agency for that purpose. Areas approved for this purpose shall be designed and operated so that they comply with the other provisions of these regulations.[22]

15. Technical Standards, Guides, and General Information to be Used in Achieving the Requirements of these Regulations

a. It will be considered that the data in this section are the best currently available to serve as guides for the fulfillment of the spirit and intent of the regulations. (51)

b. Modifications in this section will be made whenever the Agency finds it necessary in order to conform to the best practice and new information made known through continuing research.

c. *Maximum amounts of radioactive material permitted without registration.* Registration shall not be required for the possession or use of radioactive materials when the total quantities of one or more kinds of radioactive material in any one of the following groups, at any one time, is not exceeded: (77)

Group 1, 1 microcurie
Group 2, 10 microcuries
Group 3, 100 microcuries
Group 4, 1,000 microcuries

Table 1 indicates the place of individual radioactive materials in the group. Any radioactive material not listed in table 1 shall be considered as being in Group 2.

TABLE 1. *Ranges of limiting quantities detailed in table 5*

Group 1: 1 microcurie
Pb^{210}, Ra^{226}, Ac^{227}, Pu^{239}, Am^{241}, Cm^{242}, Po^{219}, At^{211}, U^{233}

Group 2: 10 microcuries
Sc^{46}, Co^{60}, Sr^{90}, Ru^{106}, Ag^{105}, Te^{129}, I^{131}, Cs^{137}, Ce^{144}, Eu^{154}, W^{181}, Re^{183}, Ir^{192}

Group 3: 100 microcuries
P^{32}, Cl^{36}, Ca^{45}, Sc^{47}, Sc^{48}, V^{48}, Fe^{59}, Zn^{65}, Ga^{72}, As^{76}, Rb^{86}, Sr^{89}, Y^{91}, Nb^{95}, Tc^{96}, Rh^{105}, Ag^{111}, Cd^{109}, Sn^{113}, Te^{127}, Ba^{140}, La^{140}, Pr^{143}, Sm^{151}, Ho^{166}, Tm^{170}, Lu^{177}, Ta^{182}, Pt^{191}, Pt^{193}, Au^{198}, Au^{199}, Tl^{200}, Tl^{204}, Pb^{203}, Th^{234}

Group 4: 1,000 microcuries
H^3, Be^7, C^{14}, Na^{24}, S^{35}, K^{42}, Cr^{51}, Mn^{56}, Fe^{55}, Ni^{59}, Cu^{64}, Ge^{71}, Mo^{99}, Pd^{103}, Pm^{147}, Ir^{190}, Au^{196}, Tl^{201}, Tl^{202}, natural uranium, natural thorium

[22] National Bureau of Standards Handbook 58 and a forthcoming report of the NCRP Subcommittee on Waste Disposal and Decontamination, "Burial of Radioactive Wastes in Soil."

d. *Permissible dose from external sources of radiation.* The following rules [23] govern the occupational exposure of individuals to radiation from sources outside the body:

Rule I. Ionizing Radiation of any Type or Types

For adults under 45 years of age whose entire body, or major portion thereof, is exposed to ionizing radiation from external sources for an indefinite period of years; the maximum permissible total weekly doses shall be 300 mrems in the bloodforming organs, the gonads, and the lenses of the eyes; 600 mrems in the skin; and the respective values of the weekly doses in millirems in all other organs and tissues of the body according to the basic permissible dose distribution. For persons 45 years of age or older similarly exposed, the corresponding maximum permissible total weekly doses shall be double the above-stated values, provided that the portion of the weekly dose in the lenses of the eyes contributed by radiation of high specific ionization does not exceed 300 mrems.

Rule II. X-rays (Roentgen Rays, Gamma Rays) with Photon Energy Less than 3 Mev

For adults under 45 years of age whose entire body, or major portion thereof, is exposed solely to X-rays with photon energies less than 3 Mev from external sources for an indefinite period of years; the maximum permissible total weekly dose shall be 300 mr measured in air at the point of highest weekly dose in the region occupied by the person, provided that the actual total weekly dose in the gonads does not exceed 300 mrads. For persons 45 years of age or older similarly exposed, the corresponding maximum permissible total weekly doses shall be double the above-stated values, provided that the actual total weekly dose in the lenses of the eyes does not exceed 600 mrads.

Rule III. Radiation of Very Low Penetrating Power (Half-Value Layer Less than 1 mm of Soft Tissue)

For adults of any age whose entire body, or major portion thereof, is exposed to ionizing radiation of very low penetrating power from external sources for an indefinite period of years; the maximum permissible total weekly dose in the skin shall be 1,500 mrems, provided that the total weekly dose in the lenses of the eyes does not exceed 300 mrems.

[23] National Bureau of Standards Handbook 59.

Rule IV–A. Local Exposure of the Hands and Forearms to Any Ionizing Radiation

For adults of any age whose hands and forearms are exposed to ionizing radiation from external sources for an indefinite period of years; the maximum permissible total weekly dose shall be 1,500 mrems in the skin, provided the respective weekly doses in millirems in all other tissues of the hands and forearms are not in excess of those that would result from exposure to ordinary X-rays at a weekly dose of 1,500 mr in the skin.

Rule IV–AX. Local Exposure of the Hands and Forearms to X-rays (Roentgen Rays, Gamma Rays) of any Photon Energy

For adults of any age whose hands and forearms are exposed solely to X-rays from external sources for an indefinite period of years, the maximum permissible total weekly dose shall be 1,500 mr in the skin.

Rule IV–B. Local Exposure of the Feet and Ankles to Any Ionizing Radiation

For adults of any age whose feet and ankles are exposed to ionizing radiation from external sources for an indefinite period of years; the maximum permissible total weekly dose shall be 1,500 mrems in the skin, provided the respective weekly dose in millirems in all other tissues of the feet and ankles are not in excess of those that would result from exposure to ordinary X-rays at a weekly dose of 1,500 mr in the skin.

Rule IV-BX. Local Exposure of the Feet and Ankles to X-rays (Roentgen Rays, Gamma Rays) of Any Photon Energy

For adults of any age whose feet and ankles are exposed solely to X-rays from external sources for an indefinite period of years, the maximum permissible total weekly dose shall be 1,500 mr in the skin.

Rule IV–C. Local Exposure of the Head and Neck to Any Ionizing Radiation

For adults whose heads and necks are exposed to ionizing radiation from external sources for an indefinite period of years; the maximum permissible total weekly doses shall be 1,500 mrems in the skin and 300 mrems in the lenses of the eyes provided the respective weekly doses in millirems in all other tissues of the head and neck are not in excess of those that would result from exposure to ordinary X-rays at a

weekly dose of 1,500 mr in the skin. For persons 45 years or older the weekly dose in the lenses of the eyes may be 600 mrems, provided that the portion contributed by radiation of high specific ionization does not exceed 300 mrems.

Rule IV–CX. Local Exposure of the Head and Neck to X-rays (Roentgen Rays, Gamma Rays) of Any Photon Energy

For adults whose heads and necks are exposed solely to X-rays from external sources for an indefinite period of years; the maximum permissible total weekly doses shall be 1,500 mr in the skin and (a) 450 mr in the lenses of the eyes of persons under 45 years of age, (b) 600 mr in the lenses of the eyes of persons 45 years of age or older.

Rule V–A. Accidental or Emergency Exposure to X-rays (Roentgen Rays, Gamma Rays) with Photon Energy Less than 3 Mev

Accidental or emergency exposure of the whole body of adults or parts thereof to X-rays with photon energy less than 3 Mev, from external sources, *occurring only once in the lifetime of the person*, under the conditions and in the respective dosages stated below, shall be assumed to have no effect on the radiation tolerance status of that person.

(a) Exposure of the whole body—any adult. Total dose, measured in air: up to 25 r.

(b) Local exposure—any adult. Dose measured in air and additional to whole-body dose: (1) Hands and forearms, up to 100 r, (2) feet and ankles, up to 100 r.

Rule V–B. Planned Emergency Exposure

Emergency work involving high-level exposure to X-rays with photon energies less than 3 Mev shall be carried out on the basis that the person will not receive doses higher than one-half the respective doses stipulated in Rule V–A. If the doses actually received in the performance of such work do not exceed the respective maximum doses stipulated in Rule V–A, the exposure may be considered to be in the category covered by Rule V–A. Women of reproductive age shall not be subjected to planned emergency exposure.

Rule V–C. Accidental or Emergency Exposure to Other Types of Ionizing Radiation

Rules V–A and V–B are applicable to accidental or emergency exposure to ionizing radiation of any type and energy when the tissue doses resulting therefrom in the different organs and tissues of the body (expressed in rems)

do not exceed numerically the respective tissue doses in rads resulting from exposure to X–rays with photon energy less than 3 Mev, under the conditions stipulated in Rule V–A; provided, however, that the portions of the respective tissue doses in rems contributed by radiation of high specific ionization do not exceed 50 percent of the total tissue doses.

Rule VI. Exposure to X-rays for Medical Reasons

Exposure of any part of the body to X-rays resulting from ordinary medical diagnostic procedures shall be assumed to have no effect on the radiation tolerance status of the person concerned, provided that no contributory accidental or emergency exposure of the order of magnitude specified in Rules V has occurred within the previous 3 months.

In exceptional cases in which it is necessary for a person to receive in 1 week more than the basic permissible weekly organ doses, the unit of time may be extended to 13 weeks (¼ year); provided that the dose in any organ accumulated during a period of any 7 consecutive days does not exceed the respective basic permissible weekly dose by more than a factor of three; and provided further that the total dose in any organ accumulated during a period of any 13 consecutive weeks does not exceed 10 times the respective basic permissible weekly dose.

For an air dose of 300 mr/week, the critical tissue dose, including backscattering, will depend upon the energy of the X- or gamma rays and on the conditions of exposure. In general, it may be expected that the dose to the critical organ would not exceed the estimated values marked in table 2 with the superscript "b", thus $^{b}(\ )$. As the permissible dose to the gonads is specifically stated in Rule II, no superscript is applied to the gonad dose for persons under 45.

In the case of exposure to radiation of very low penetrating power (HVL$<$1 mm of soft tissue) the values specifically stated in the Rules are 1,500 mrems for the skin and 300 mrems for the lens of the eye, and apply to adults of any age. Because with this radiation the bloodforming organs and gonads would receive a negligible dose, none is stipulated. In practice, however, the same individual may be exposed also to penetrating radiation. In this case the limits for these critical organs should be the same as usual. Because they are different for the two age groups, they are given separately. The lens dose for age 45 and over has been arrived at by analogous reasoning. These additional values are marked $^{c}[\ ]$ in table 2.

TABLE 2. *Maximum permissible total weekly doses in critical organs under various conditions of external exposure*

Conditions of exposure / Critical organ				Skin	Blood-forming organs	Gonads	Lens of the eye	Air dose*
Part of body	Radiation	Unit	Adult age	Weekly doses in significant volume in region of highest dose rate				
								mr
Whole body	Any radiation	mrem	Under 45	600	300	300	300	------
			Over 45	1,200	600	600	[a] 600	------
Whole body	X-rays and gamma rays (up to 3 Mev)	mrad	Under 45	[b] (450)	[b] (400)	300	[b] (450)	300
			Over 45	[b] (900)	[b] (800)	[b] (800)	600	600
Whole body	Any radiation with HVL<1 mm of soft tissue.	mrem	Under 45	1,500	[c] [300]	[c] [300]	300	------
			Over 45	1,500	[c] [600]	[c] [600]	[c] [600]	------
Hands and forearms	Any radiation	mrem	Under 45	1,500	[d] 300	300	300	------
			Over 45	1,500	[d] 600	600	[a] 600	------
Feet and ankles	Any radiation	mrem	Under 45	1,500	[d] 300	300	300	------
			Over 45	1,500	[d] 600	600	[a] 600	------
Head and neck	Any radiation	mrem	Under 45	1,500	[d] 300	300	300	------
			Over 45	1,500	[d] 600	600	[a] 600	------

*Air dose means that the dose is measured by an appropriate instrument in air in the region of highest dose rate to be occupied by a person, without the presence of the human body or other absorbing and scattering material.

[a] Including not more than 300 mrems of radiation of high specific ionization.

[b] Rough estimates of maximum values resulting from specified air doses, under practical conditions of exposure.

[c] Limits for concurrent exposure to penetrating radiation.

[d] In main portion of body. Not in region of highest dose rate (hand, foot, or head).

In the case of local exposure of the extremities or head and neck, no age distinction is made in the Rules. Again, because whole-body exposure may also occur, the appropriate figures for all critical organs are included. Blood-forming tissue (principally bone marrow) in the designated part of the body (hands, etc.) is in the "region of highest dose rate" and the doses in table 2 should be for a significant volume in this region. However, the high dose in this portion of the bloodforming organs is purposely disregarded in this case. The values marked with the superscript "d" apply to the main portion of the body.

e. *Maximum permissible neutron flux densities.* Neutrons are most commonly measured in terms of their flux densities. Table 3 gives the maximum permissible flux densities for neutrons of various energies.[24]

f. *Relative biological effectiveness.* The relative biological effectiveness (RBE) applicable to exposure to radiation from external sources is given in table 4.[24]

[24] Recommendations of International Commission on Radiological Protection (1953), Brit. J. Radiol. Suppl. No. 6 (1955).

TABLE 3. *Maximum permissible neutron flux densities*

Neutron energy	Neutron flux
	n/cm²/sec
0.025 ev	2,000
10 ev	2,000
10 kev	1,000
0.1 Mev	200
0.5 Mev	80
1 Mev	60
2 Mev	40
3 to 10 Mev	30

In these calculated values, it is assumed that the RBE for gamma rays is 1, and the RBE for protons is 10, in accordance with table 4. Based on 40 hr/week exposure.

TABLE 4. *RBE values*

Radiation	RBE	Biological effect
X-rays, gamma rays, electrons, and beta rays of all energies.	1.0	Whole-body irradiation (blood-forming organs critical).
Fast neutrons and protons up to 10 Mev.	10	Whole-body irradiation (cataract-formation critical).
Naturally occurring alpha particles.	Compare with 0.1 microcurie Ra, otherwise =10.	Carcinogensis.
Heavy recoil nuclei	20	Cataract formation.

g. *Exposure to sources of radiation within the body.* Table 5 gives the maximum permissible amounts of radioisotopes in the human body and maximum permissible concentrations in air and water.[25]

h. In the case of occupational exposure of 8 hr a day (assuming half the daily consumption of air and water in the 8-hr work period), 5 days a week, and 49 weeks a year, the values of maximum permissible concentrations of radioisotopes in air and water *in the working area* may be increased by a factor of 3 above those values listed in table 5, provided no nonoccupational exposure to radiation occurs.

[25] Table 3, National Bureau of Standards Handbook 52.

TABLE 5. *Maximum permissible amounts of radioisotopes in total body and maximum permissible concentrations in air and water*

Group	Radioisotope	Column I[a] Microcuries per milliliter of air	Column II[a] Microcuries per milliliter of water	Column III Microcuries in total body
---	A^{41}	5×10^{-7}	5×10^{-4}	30
2	Ag^{105}	1×10^{-5}	2	18
3	Ag^{111}	3×10^{-5}	4	36
1	Am^{241}	3×10^{-11}	1×10^{-4}	0.06
3	As^{76}	2×10^{-6}	0.2	10
1	At^{211}	3×10^{-10}	2×10^{-6}	6×10^{-4}
3	Au^{198}	1×10^{-7}	3×10^{-3}	10
3	Au^{199}	2.5×10^{-7}	7×10^{-3}	28
3	$Ba^{140}+La^{140}$	6×10^{-8}	2×10^{-3}	5
4	Be^{7}	4×10^{-6}	1	670
4	C^{14}	5×10^{-7}	3×10^{-3}	250
3	Ca^{45}	3×10^{-8}	5×10^{-4}	65
3	$Cd^{109}+Ag^{109m}$	7×10^{-8}	7×10^{-2}	40
2	$Ce^{144}+Pr^{144}$	7×10^{-9}	4×10^{-2}	5
3	Cl^{36}	4×10^{-7}	2×10^{-3}	200
1	Cm^{242}	2×10^{-10}	9×10^{-4}	0.05
2	Co^{60}	1×10^{-6}	2×10^{-2}	3
4	Cr^{51}	8×10^{-6}	0.5	390
2	$Cs^{137}+Ba^{137m}$	2×10^{-7}	1.5×10^{-3}	90
4	Cu^{64}	6×10^{-6}	8×10^{-2}	150
2	Eu^{154}	6×10^{-9}	3×10^{-2}	22
---	F^{18}	1×10^{-4}	0.9	24
4	Fe^{55}	6×10^{-7}	4×10^{-3}	1,000
3	Fe^{59}	1.5×10^{-8}	1×10^{-4}	11
3	Ga^{72}	3×10^{-6}	9	8
4	Ge^{71}	4×10^{-5}	9	67
4	H^{3} (HTO or T_2O)	2×10^{-5}	0.2	10^{4}
3	Ho^{166}	3×10^{-6}	23	17
2	I^{131}	5×10^{-9}	3×10^{-5}	0.7
4	Ir^{190}	7×10^{-7}	1×10^{-2}	21
2	Ir^{192}	5×10^{-8}	9×10^{-4}	3.4
4	K^{42}	2×10^{-6}	1×10^{-2}	20
3	La^{140}	1×10^{-6}	1	24
3	Lu^{177}	5×10^{-6}	24	78
4	Mn^{56}	3×10^{-6}	0.15	2

TABLE 5. *Maximum permissible amounts of radioisotopes in total body and maximum permissible concentrations in air and water*—Con.

Group	Radioisotope	Column I[a] Microcuries per milliliter of air	Column II[a] Microcuries per milliliter of water	Column III Microcuries in total body
4	Mo^{99}	2×10^{-3}	14	50
4	Na^{24}	2×10^{-6}	8×10^{-3}	15
3	Nb^{95}	4×10^{-7}	4×10^{-3}	90
4	Ni^{59}	2×10^{-5}	0.25	39
3	P^{32}	1×10^{-7}	2×10^{-4}	10
3	Pb^{203}	6.5×10^{-6}	0.1	57
4	$Pd^{103}+Rh^{103}$	7×10^{-7}	1×10^{-2}	6
4	Pm^{147}	2×10^{-7}	1	120
1	Po^{210} (sol.)	2×10^{-10}	3×10^{-5}	0.02
1	Po^{210} (insol.)	7×10^{-11}	----------	7×10^{-3}
3	Pr^{143}	7.5×10^{-7}	0.4	29
1	Pu^{239} (sol.)	2×10^{-12}	1.5×10^{-6}	0.04
1	Pu^{239} (insol.)	2×10^{-12}	----------	.008
1	$Ra^{226}+1/2$ dr[b]	8×10^{-12}	4×10^{-8}	.1
3	Rb^{86}	4×10^{-7}	3×10^{-3}	60
2	Re^{183}	8×10^{-6}	8×10^{-2}	35
3	Rh^{105}	1×10^{-6}	1.5×10^{-2}	9
---	$Rn^{222}+$dr[b]	[c]1×10^{-7}	2×10^{-6}	----------
2	$Ru^{106}+Rh^{106}$	3×10^{-8}	0.1	4
4	S^{35}	1×10^{-6}	5×10^{-3}	300
2	Sc^{46}	7×10^{-8}	0.4	6
3	Sm^{151}	1×10^{-8}	.2	420
3	Sn^{113}	6×10^{-7}	.2	80
3	Sr^{89}	2×10^{-8}	7×10^{-5}	2
2	$Sr^{90}+Y^{90}$	2×10^{-10}	8×10^{-7}	1
3	Tc^{96}	3×10^{-6}	3×10^{-2}	5
3	Te^{127}	1×10^{-7}	3×10^{-2}	4
2	Te^{129}	4×10^{-8}	1×10^{-2}	1.3
3	Th^{234}	6×10^{-7}	3	120
4	Th—natural (insol.)	3×10^{-11}	----------	0.002
4	Th—natural	3×10^{-11}	4×10^{-7}	.01
3	Tm^{170}	5×10^{-8}	0.25	19
1	U^{233} (sol.)	1×10^{-10}	1.5×10^{-4}	0.04
1	U^{233} (insol.)	1.6×10^{-11}	----------	.008
4	U—natural (sol.)	1.7×10^{-11}	7×10^{-5}	.02
4	U—natural (insol.)	1.7×10^{-11}	----------	.009
3	V^{48}	1×10^{-6}	0.5	20
---	Xe^{133}	4×10^{-6}	4×10^{-3}	300
3	Xe^{135}	2×10^{-6}	1×10^{-3}	100
3	Y^{91}	4×10^{-8}	0.2	15
3	Zn^{65}	2×10^{-6}	6×10^{-2}	430
	All other beta or gamma emitters	1×10^{-9}	1×10^{-7}	----------
	All other alpha emitters	5×10^{-12}	1×10^{-7}	----------

[a] The values given in columns I and II apply to continuous exposures for 24 hr a day. Where exposure is incurred only during a work day of 8 hr, the values in columns I and II may be multiplied by a factor of 3.

[b] dr stands for daughter products.

[c] The limit given in NBS Handbook 52 is 10^{-8} mc/ml. The new value, 10^{-7} mc/ml was adopted by the International Commission on Radiological Protection 1953, and is now acceptable in the United States.

i. *Recommendations of the National Committee on Radiation Protection.* Recommendations on protection against the injurious effect of radiation, published as Handbooks by the National Bureau of Standards, are listed below:

H42 Safe Handling of Radioactive Isotopes.
H48 Control and Removal of Radioactive Contamination in Laboratories.
H49 Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users.
H51 Radiological Monitoring Methods and Instruments.
H52 Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water.
H53 Recommendations for the Disposal of Carbon-14 Wastes.
H54 Protection Against Radiations from Radium, Cobalt-60, and Cesium-137.
H55 Protection Against Betatron-Synchrotron Radiations up to 100 Million Electron Volts.
H56 Safe Handling of Cadavers Containing Radioactive Isotopes.
H58 Radioactive-Waste Disposal in the Ocean.
H59 Permissible Dose From External Sources of Ionizing Radiation.
H60 X-ray Protection (Revision of H41).
Burial of Radioactive Wastes in Soil (in preparation).

Submitted for the National Committee on Radiation Protection.

LAURISTON S. TAYLOR, *Chairman.*

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