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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

PROTECTION OF RADIUM DURING AIR RAIDS

NATIONAL BUREAU OF STANDARDS HANDBOOK H38

U. S. DEPARTMENT OF COMMERCE
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National Bureau of Standards Handbook H38

PROTECTION OF RADIUM DURING AIR RAIDS

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PREFACE

Subsequent to the involvement of this country in the present war, the National Bureau of Standards has received numerous requests from users of radium for advice regarding its storage during air raids. These requests indicate that there is a need for recommendations that will reduce hazards to individuals from radium which might be dispersed over considerable areas as a result of air raids. Inasmuch as the National Bureau of Standards has for the past 30 years standardized nearly all the radium sold in this country, we were asked for recommendations to meet the present situation as adequately as possible. Accordingly, the following committee was appointed, with the request that recommendations be drawn up regarding the storage of radium and the protection of individuals from the effects of radium under conditions that might arise in connection with the present emergency:

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Dr. G. Failla, Memorial Hospital New York, N. Y.
Dr. John E. Rose, Tumor Clinic, U. S. Marine Hospital, Baltimore, Md.
Dr. Curtis F. Burnam, The Kelley Clinic, 1418 Eutaw Place, Baltimore, Md.
Dr. Harrison S. Martland, Newark City Hospital, Newark, N. J.
Dean George B. Pegram, Columbia University, New York, N. Y.
Lt. Col. Sherwood Smith, Corps of Engineers, War Department, Washington, D. C.

The recommendations in the following pages are the result of their joint suggestions and discussions. I thank the committee for their cooperation in the preparation of the Handbook.

Lyman J. Briggs, *Director.*

PROTECTION OF RADIUM DURING AIR RAIDS

CONTENTS

I. INTRODUCTION

In devising any procedure for protecting radium, a decision must be made at the outset as to the degree of protection to be attained. The maximum protection would require safety of the radium in case of a direct hit by an explosive bomb of the largest caliber. Such protection would be very expensive in all cases and almost impossible in others, on the basis of explosive bombs now known to be in use. The introduction of new bombs might render obsolete installations now regarded as bombproof for a direct hit. Therefore, it is the opinion of the committee that methods should be recommended that insure reasonable safety without attempting to provide complete protection from a direct hit. Even for this situation, due weight has been given to reducing the possible destructive effects, so that in most cases the radium would be recoverable, although it might not survive with its containers intact.

In arriving at the recommendations herein set forth, the committee has kept before it the desirability of simple expedients that can be put into operation quickly. Due attention has been given to keeping radium in use with as little disturbance of routine and exposure of personnel as is consistent with reasonable protection. The committee has also been guided by costs and the availability of materials in the present emergency.

II. PROTECTION OF PERSONNEL

One aspect of the problem of providing protection for radium during air raids is that of protecting individuals from radium poisoning. After a careful investigation of the subject, the committee reached the conclusion that the chances of such harmful effects are very remote, provided the suggestions for protecting the radium from dispersal are followed. In case of a direct hit, where radium containers may be broken, the radon will be released into violently agitated air, so that it will never reach a dangerous concentration. In the case where the containers are smashed into fragments (and these cases will be very rare, if the radium has any reasonable amount of protection), there would be considerable radium in the dust blown up by the explosion. It is hardly conceivable, however, that sufficient dust to cause injury could be inhaled by any person who survives the explosion by virtue of distance or intervening structures. It is, nevertheless, recommended that rooms in which large quantities of radium are kept be evacuated by all personnel during an air raid. There remains only the question of protecting individuals who are assigned to the task of retrieving radium from a demolished building or clearing the debris. This matter is discussed later.

III. PROTECTION OF RADIUM

In discussing the protection of radium from dispersal as the result of impact of explosive bombs, it is convenient to deal separately with the three usual types of containers.

IIIa. Sealed Metal Tubes and Needles.—The most general type of radium preparation is the sealed metal tube or needle. These preparations are small, and a considerable number can be stored in a small space. They will stand considerable rough treatment and will survive temperatures up to 200° C without damage. The protection of these preparations can be secured by the same general procedure regardless of the number. Therefore, the suggestions given below apply equally to small and to large amounts of radium in sealed metal containers. When large amounts are to be protected, several repositories would have to be provided. This has the advantage of decreasing the exposure to radiation of persons handling the radium, as well as decreasing the possibility of the loss of the entire supply of radium.

In making recommendations for the protection of sealed radium preparations, the committee is aware that situations exist where no additional precautions are necessary beyond those customary in storing of radium. An example would be the central portions of high, modern steel and concrete buildings. (It is important that radium should be located four stories below the roof in tall buildings. If given lateral protection the first floor is satisfactory. Intermediate floors are even better.)

IIIb. Special Enclosures for Tubes and Needles.—The following alternative recommendations are intended for those situations where there is little structural protection from bombs:

1. A steel safe with walls 1½ inches thick and the usual lead lining. Steel of this thickness is equivalent to ¾ inch of lead. This safe would replace the usual radium safe with thin steel walls and would cause no changes in routine. Although this is the most convenient solution to the problem, the supply of such safes is undoubtedly limited, and in the larger sizes they may be impossible to obtain or install on account of structural limitations.

2. The second alternative is to store the radium preparations in steel cylinders with walls 1½ inches thick. These may be placed in the usual safe or other regular storage container. The cylinders should be provided with a screw plug or other closing device so designed that it will not open when the container is thrown about with great force. This method involves slight changes in the routine of handling radium, but proper care should be exercised to prevent overexposure of personnel to radiation.

3. The third alternative is to provide a block of reinforced concrete from 5 to 7 feet on each edge, with a steel pipe of suitable diameter mounted centrally and extending to the center of the block. This pipe should have a smooth bend, approximately at right angles. The pipe should enter the block from the side and be inclined slightly so that a container for the radium can slide to the center of the concrete block. An alternative arrangement is to use a straight piece of pipe closed at the top by a regulation pipe coupling and threaded plug. This arrangement may be convenient and desirable in some instances. It affords better protection than the 1½-inch steel safe or cylinders, but it introduces greater changes in routine. Protection of personnel against over-exposure to radiation should be given careful attention.

IIIc. Radium in Use During Raid.—If an air raid occurs during ordinary working hours, a large part, if not all, of the radium supply in any one place, may be in use on patients. In large hospitals, at least, rules have been worked out and drills instituted for the evacuation of patients to a relatively safe part of the building. This would automatically provide some degree of safety for the radium which happens to be on a patient. However, in the excitement of the moment radium may be forgotten and, aside from air-raid damage, something may happen which will result in harm to the personnel as well as the radium. Therefore, definite steps should be taken to make sure that those charged with the evacuation of patients take special precautions regarding radium cases. The committee makes the following suggestions to take care of this situation:

1. A large tag of distinctive color (red) with the word "Radium" on it should be attached to the bed of a patient or to the patient himself at the time that radium is applied. (In many institutions this is being done at present as a precaution against loss of radium.)

2. In case of air-raid alarm, bed patients with radium are to be moved to the safest part of the building, without removing the radium.

3. In the case of ambulatory patients, radium should be removed before they are taken to the part of the building assigned to them. The radium should be put immediately

in a protective container and taken care of in accordance with the general provisions outlined in this report.

4. Patients undergoing radium "bomb" treatment should be evacuated to the assigned place. If the apparatus is provided with a device which shuts off the radiation beam, the nurse or technician administering the treatment must set the radium bomb in the closed position as soon as the air-raid alarm is received.

Local conditions and circumstances may dictate other precautions or measures to be taken. In working out the details for any particular place, it should be borne in mind that protection of personnel and patients from possible radium injury is the most important consideration. This refers not only to radium injuries which may result from bomb explosions or fires but also to injuries which may result from the mere carrying out of the precautionary measures adopted. Thus, removal of radium applicators from patients (which in general is desirable) entails exposure of personnel to radiation every time that an air-raid alarm occurs. Removal of radium needles from a patient is objectionable in addition for therapeutic reasons. A proper balance between such conflicting factors cannot be determined in advance of actual experience and may have to be modified from time to time in any case. The main point is to provide the necessary physical means of protection as soon as possible—materials and labor may not be available later. Then a definite procedure best adapted to local requirements should be worked out, personnel should be carefully instructed, and regular drills should be carried out. However, no radium should be handled in the course of the drills. "Dummy" preparations and applicators should be used instead. The importance of carrying out all steps in an orderly manner, and expeditiously, is obvious. For this reason protective containers should be large enough to house radium applicators without taking them apart. Furthermore, no radium that is not in actual use should be left outside of the protective enclosure at any time.

Radon applicators do not constitute a serious hazard in case of air raids. Nevertheless, some definite procedure should be adopted to keep them under proper surveillance, to make sure that they are not mislaid and perhaps create a radiation hazard.

IV. RADIUM "BOMBS"

The second general type of container in which radium is used is the so-called "bomb" or "pack." It consists of a large mass of lead or mercury, within which radium in sealed tubes is mounted. The amount of radium in "bombs" ranges from 1 to 10 grams, and about a dozen are in use in this country. The massive container is usually supported by a strong steel structure with suitable arrangements to permit positioning of the radiation beam in proper relation to the patient.

The construction of these devices and the flexibility of adjustment required clinically, make it impossible to add steel shields for better protection. The obvious method of removing the radium from the "bomb" when not in use or in case of air-raid alarm cannot be recommended because in the design of existing apparatus special precuations were taken to insure that the radium could not be removed readily (to safeguard against theft). To provide for removal of the radium with safety to the operator, an entirely different type of apparatus would have to be installed at a cost of several thousand dollars. (Radium "bombs" embodying this feature are in use in England.) The problem of protecting the radium would still remain. Having adopted the criterion that complete protection of radium against all risks pertaining to air raids is impractical, it is only necessary to consider measures which would insure essentially the same degree of protection as recommended for radium in sealed containers. The committee feels that the radium in a "bomb" is surrounded by sufficient dense material (several centimeters of lead or mercury) to prevent disruption of the tubes and dispersal of the radium under severe impact in case the container should be blown about bodily. In view of the large amounts of radium used in "bombs," the committee's recommendations for the evacuation of rooms containing radium is particularly applicable in this case.

V. RADON PLANTS

In this case the problem of providing the same degree of protection as for radium in other forms is more complex. In a radon plant the radium is in solution in one or more small glass flasks connected by glass tubing to the collecting apparatus. The whole system must be kept under vacuum and must be operated at regular intervals (usually once a day) to maintain the required supply of radon for the treatment of patients.

V (a). Safeguarding Operator.—A technician in operating a radon plant routinely must guard against two sources of danger: (1) Exposure to radiation, and (2) breathing of radon that may escape into the atmosphere. In practice, rather elaborate precautions are taken to minimize these dangers. It is obvious, therefore, that the method of protecting radium from air raids in this case must be such as will not increase appreciably the health hazards to the technician in his daily tasks.

V (b). Arrangement of Radium Bulb and Connections.—In practically all radon plants the glass radium flask is surrounded by a lead-lined metal cup with a split lead cover. Absorbent cotton is packed around the glass flask in the metal cup to prevent splashing of the radium solution in case the flask should break under vacuum. This unit is housed in an ordinary fire-resistant safe having a thick inner lining of lead, and the connecting glass tubing passes through a small hole in the top. The glass flask is supported in the center of the metal cup by means of a clamp fastened to the projecting neck of the flask. The cup rests on the lead bottom of the safe but is not fastened thereto. Usually the safe rests on a concrete block slightly larger than the base of the safe and about 3 feet high, or on an angle-iron frame of similar dimensions. Under existing conditions, violent jarring could readily displace not only the metal cup but the safe as well. Obviously the connecting glass tubing may be broken even by distant explosions. Such a break is very troublesome not only because it interrupts service for 2 or 3

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days [1] but primarily because the necessary repairs can hardly be made without inhalation of radon and exposure to radiation on the part of the operator. The committee, therefore, recommends that provisions be made to prevent motion of the metal cup within the safe and of the safe itself in case of distant explosions.

As a simple means of fastening the metal cup and the clamp holding the radium flask, the committee suggests a plaster of paris cast, filling the safe to about the height of the metal cup. This can be applied readily by fastening a sheet-iron dam to the safe with adhesive plaster and then pouring a thin mixture of plaster of paris into the compartment thus formed. Since heat is released when plaster of paris sets, it is advisable to leave the door open and to blow air into the safe until the plaster has set and is cold. (If considerable heat is allowed to reach the radium solution, which is under vacuum, it may boil and splash.) It may be well also to ventilate the safe from time to time until the plaster is dry, to prevent rusting of the lock.

V (c). Anchoring Safe Which Contains Radium Solution.—Fastening of the safe onto the concrete block or angle-iron frame presents a more difficult problem, especially since conditions vary considerably from one plant to another. The lead-lined safe may be weigh close to a ton, and to be at all effective the reinforcing structure must be quite strong. Provisions should be made against lateral motion in any direction and against upward motion as well. The addition of properly reinforced-concrete barriers around the safe, from the floor up (leaving an opening for the door), would serve the purpose very well. However, the floor load limit in most installations precludes the utilization of this arrangement. Accordingly, a structural-steel frame of some sort is the practical means. Suggestions for the design of such a frame are embodied in figures 1 and 2.

V (d). Support for Lead Shields.—A thick-walled lead pipe usually surrounds the glass tubing which comes through the top of the safe. The support for this pipe is not intended to withstand severe shocks and should be reinforced by steel

[1] Once air has come in contact with the radium solution, the apparatus must be operated for 2 or 3 days before the radon can be collected in concentrated form.

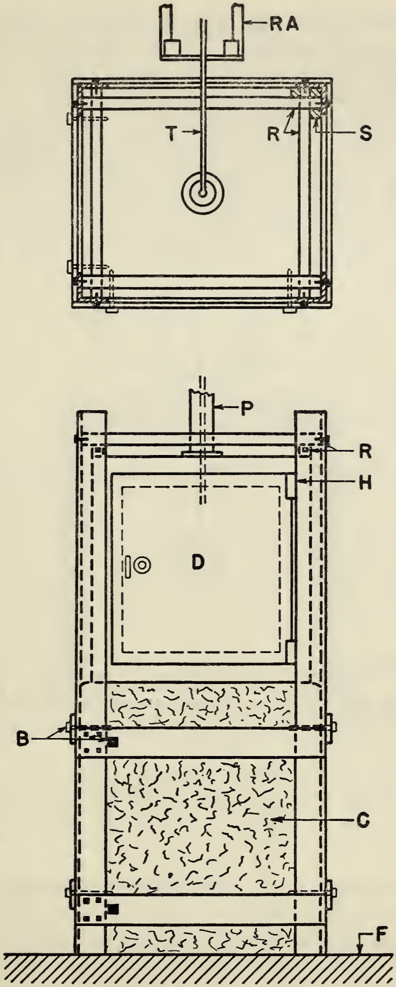

FIGURE 1.—*Suggested means for anchoring radon safe when situated on a concrete block.*

B, Expansion bolts in concrete; *C*, concrete block; *D*, door of safe; *F*, floor; *H*, hinge (must clear angle-iron frame); *P*, lead pipe; *R*, tie rods (may be placed higher than shown to clear glass-tube housing in case there is no lead pipe); *S*, wood blocks or mortar filling between angle irons and corners of safe; *T*, glass tubing; *RA*, radon apparatus.

straps attached either to the angle-iron framework mentioned above, or otherwise. If the lead pipe is long, it may buckle and break the enclosed glass tube. Reinforcement against buckling should be provided in such cases.

V (e). Provision for External Break in Connecting Glass Tube.—The protective measures suggested thus far are intended primarily to prevent breakage of the glass parts inside the safe in case of moderate shock. The rest of the glass apparatus is usually mounted on a steel frame with legs embedded in concrete. Accordingly, motion of the top of

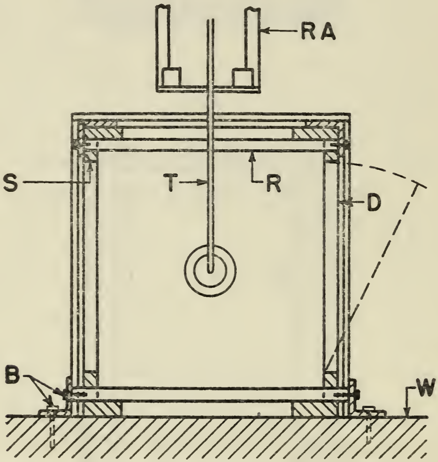

Figure 2.—*Suggested method of anchoring radon safe to wall where safe is located on a concrete block against a wall.*

B, Expansion bolts in concrete; *D*, door of safe; *R*, tie rods; *RA*, radon apparatus; *S*, wood blocks or mortar filling between angle irons and corners of safe; *T*, glass tubing; *W*, wall.

the frame and consequent breakage of glass may be expected to occur. It is felt that a break in the radon-containing tubing at some point between the lead pipe on top of the safe and the top of the radon collection apparatus proper is apt to cause less trouble than a break elsewhere in the same line. For this reason it may be well to leave the steel frame of the apparatus unsupported at the top.

V (f). Provision for Automatic Severance of Bulb Inside Safe in Case of Severe Explosion.—It is conceivable that under certain conditions the safe may overturn, and yet the radium flask and even the connecting tubing inside the safe may remain intact. There would then be the possibility of the radium solution leaking out of the flask and the safe through the connecting glass tube or otherwise. It is highly desirable to prevent the radium solution from leaking out of the safe in case of blasts that are not violent enough to burst it open. To this end, means should be provided to insure breakage of the glass tubing near the center of the safe in case it should overturn suddenly. The safe should also be closely packed with absorbent cotton or similar material to hold the spilled solution within the safe. Since the eventuality against which we wish to guard depends on a highly improbable combination of circumstances, the means adopted should not be such as may cause breakage of the glass tubing at other times. The committee feels that the arrangement shown in figure 3 fulfils the necessary requirements. It has the advantage that it can be installed without cutting the glass tubing in the safe. Furthermore, it also serves the purpose of holding the split lead cover on the metal cylinder around the radium flask and supporting to some extent the lead lining of the safe. It is out of the question to seal the safe so as to prevent the radium solution from leaking out under all conditions, even if the safe remains intact. For one thing, the hole through which the glass tubing passes could not be closed. On account of its extreme simplicity (not through any faith in its efficacy), it is suggested that all cracks between the door and the front wall of the safe be sealed with Scotch tape.

V (g). Recovery of Radium in Case of Severe Damage.—An explosion of sufficient violence to knock over the radium safe (after it has been reinforced as previously suggested) is liable to wreck part of the building and to start a fire. It is reasonable to assume that a fire which would not melt the safe would cause no serious additional harm to the radium inside the safe than had already been done. Judging from prior experience in the recovery of radium accidentally

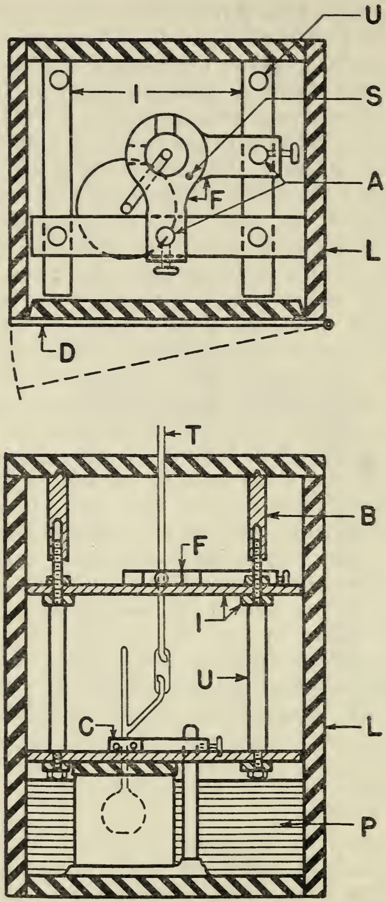

FIGURE 3.—*Suggested arrangement inside radon safe to insure severance of glass tubing inside safe in case of severe shock*

A, 1-inch stud about 2 inches high, with groove for set screw. Forks *F* are installed last and are free to rotate about studs *A*, except for shear pin *S*; *B*, front tie rods provided with anchors in top lead sheet; *C*, clamp for glass tube just above bulb; *D*, door of safe; *F*, forks for breaking glass tube; *I*, 1½-inch by ½-inch iron strips; *L*, lead lining of safe; *P*, plaster of paris; *S*, shear pin. Small pin of wood or other fragile material which will prevent movement of forks, *F*, under ordinary jars; *T*, glass tubing; *U*, uprights, ¾-inch iron rod.

thrown into incinerators, even if the safe should melt, the radium would remain more or less localized. However, in the process of extinguishing a fire in the building, or through the bursting of water mains, the safe may be flooded, and in time the radium solution would be washed out. This danger is greatest in those plants housed below street level. If the safe remains on its pedestal, the water would have to rise more than 3 feet before it could seep into the safe. Conceivably, from a broken street main, water could pour into a basement by way of the radon plant room. If the door of this room is closed, as normally it would be, the water might well rise above the level of the safe. The obvious thing to do to overcome this difficulty is to provide large holes or louvers at the bottom of the door or, better still, to close the room with an iron grille door. Whether this or any other precaution against flood is necessary depends on the particular layout of the plant. It is suggested, therefore, that those in charge of radon plants located below street level give careful consideration to this problem and take appropriate protective measures.

V (h). Protection at Windows.—In line with the idea of guarding against the release of radon, it is suggested that the windows in the radon apparatus room be provided with strong metal screens to stop broken glass or other light splinters which might otherwise reach the glass apparatus. In view of the existing scarcity of metals, wooden shutters on the inside of the windows could be used instead, and these could be obtained more promptly. The shutters should be kept closed at night and during air raids in daytime. If properly constructed, they will serve also for black-out purposes. When the radon plant is located below street level, windows which open into an areaway should be boarded up and the areaway filled with sand or earth, making ample provisions for proper drainage.

V (i). Ventilation of Radon Apparatus Room.—It is important to bear in mind that good artificial ventilation of the radon apparatus room is essential—now more than ever—on account of the more probable radon leakage. If anything done to the windows interferes with the existing ventilating system, an equivalent ventilating system must be provided in some other way.

V (j). Barricades for Radon Plant.—To improve further the protection of radon plants, means should be provided to stop larger missiles which might be flying about in case of a fairly close hit. Concrete barriers or sand bags properly stacked, and held in place firmly with iron or wood frames, around the safe would serve this purpose. However, in most installations the load capacity of the floors precludes the use of such barriers. It is suggested that they be used in cases in which the safe and apparatus rest on a solid foundation. Loading to the limit a floor supported by beams would probably increase the danger to the radium.

V (k). Evacuation of Personnel From Radon Plant Room.—The general recommendation that rooms in which radium is kept must be vacated during air raids applies with particular emphasis to the case of radon plants. In addition, since the radium is in solution and the safe is usually of very light construction, the chances of dispersal of radium in case of a violent explosion are greater. It is suggested, therefore, that rooms adjacent to a radon plant be vacated also during air raids.

VI. SALVAGE

The intent of the committee's recommendations is not so much to minimize the loss of radium but rather to prevent, so far as can be foreseen, danger to human life inherent in the peculiar properties of radium. A certain hazard exists in the handling of radium under normal conditions. The committee has refrained from making recommendations which would materially increase this hazard to quite a large number of radium users. Danger to humans exists from what may happen at the time of an explosion and subsequently. The recommendations thus far made relate largely to protection of personnel and people who may be within the danger zone at the time of an explosion. The measures suggested, however, tend also to prevent wide dispersal of radium and thus simplify the problem of possible recovery and clearing of the debris of dangerous concentrations of radium.

VI (a). Preliminary Survey.—When radium is within the highly destructive range of an explosion, the material may be dispersed in the wreckage. It is then very important to determine, as soon as possible (and later if indicated), the distribution of the radium in the bombed area. The owner, or an individual responsible for the radium, who is well acquainted with the premises, should make a preliminary search as soon as access to the bombed area is permitted. If the safe or other protective enclosure cannot be found, or has been burst open, a competent physicist should be called upon to undertake the search.

VI (b). Detailed Search With Sensitive Detecting Device.—The search should have the following objectives: (1) To locate the radium if it is still in more or less concentrated form, (2) to determine whether in any particular spot within the range of the explosion there is a sufficient concentration of radium to constitute a health hazard. As regards the first objective, the search may be conducted by means of a sensitive Geiger-Müller counter or other suitable device. What to do after the radium has been located depends on circumstances. If the safe or other protective enclosure is badly smashed, the radium (in tubes or needles) may still be in good condition, but may be difficult to remove. Recovery of the radium in this case should be attempted only by those who have had experience in handling it or under their direction. Under no circumstances should an acetylene torch be used to provide access to the radium tubes, unless elaborate precautions are taken to carry away with certainty, and safely dispose of, any radioactive fumes which may be released by the intense heat. In any such case, the approximate position of the radium should be determined first by gamma-ray tests and the torch used judiciously.

VI (c). Disposition of Debris Containing Radium.—If the protective container has been smashed open and the radium is mixed with considerable debris, and yet is concentrated within a small area, the debris should be collected and either saved under proper conditions for future recovery of the radium or be dumped in a place where it can never do any harm (preferably into a large body of water). In either case, water should be sprayed over the debris to prevent workers from inhaling radioactive dust. If water is used sparingly, to just wet the debris, little or no radium will be washed away. As an additional precaution when the amount of radium in the debris is large, it is suggested that all those engaged in this work, or in supervising it, wear dust-proof masks (e. g., simple masks with wet filters).

VI (d). Dealing With Widely Dispersed Radium.—If the radium has been scattered over a large area, a search should be made to locate any possible spots of high concentration, which then should be dealt with in the manner outlined above. The extent of the search obviously depends on local conditions and on the amount of radium involved. Due consideration should be given to the possibility of danger to workers in the process of restoring the premises. In particular, when a building has collapsed, the radium may be buried under a big pile of debris, and no danger exists until the workers clearing away the wreckage reach this level.

Under certain conditions the radium may be mixed with very large amounts of earth or other material. The decision as to whether any health hazard exists, or is apt to arise in the future, and what corrective measures are indicated should rest on the physicist surveying the premises. The decision should be based upon careful investigations conducted at the proper time or times between the occurrence of the explosion and the restoration of the premises. The investigation should cover all three sources of danger: (1) Radioactive dust, (2) radon, and (3) radiation.

VI (e). Recovery of Radium from Debris.—In view of the lack of facilities in this country for the extraction of radium, it is questionable whether material with even as high a radium content as in rich ores (say 1 part in 10 million or 1 gram in 7 cubic yards) is worth saving. Whatever material of reasonable concentration is not stored properly for future recovery of the radium should be disposed of permanently, as already suggested. As a general rule, it is best to dump as much of the radium-contaminated debris as possible. (See section VI (c).)

VII. PROTECTION FROM FIRE

The protection of radium from fire depends on the fire protection afforded the building in which it is located. Consequently, it is important to ascertain that proper facilities for fire protection are available and fire regulations are enforced.

VIII. RADIATION HAZARDS

In carrying out the recommendations of the committee for protecting radium, it is important to observe at all times the regulations set forth in NBS Handbook H23, Radium Protection, so that no additional radiation hazards will be created.

IX. DANGER ZONES

On the basis of present information, the committee regards it as imperative that the suggested precautions be taken at once by all owners of radium within 500 miles of any coast line. Although it is unsafe to make definite predictions, it would seem that there is little chance of bomb damage in areas more remote from the coasts of the country.

X. SPECIAL PROBLEMS

There may exist conditions of radium storage and use not adequately covered by the recommendations of this report. Therefore, the committee invites correspondence regarding special problems. Detailed information should be given in correspondence to enable the committee to make suitable recommendations promptly. The committee will be glad to cooperate also in the solution of any problem arising from damage or destruction of a building containing radium. It is urged that in such a case the owner or user of the radium report the accident to the committee as soon as possible. It will expedite matters to address all correspondence to the National Bureau of Standards.

Washington, April 2, 1942.

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Calvert