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DEPARTMENT OF DEFENSE

ARMED FORCES SPECIAL WEAPONS PROJECT

WASHINGTON 25, D. C.

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ADDRESS REPLY TO
THE CHIEF, ARMED FORCES
SPECIAL WEAPONS PROJECT

SWPRI 933

12 DEC 1955

MEMORANDUM FOR: Members, Panel on Radiological Instruments

SUBJECT: Transmittal of Draft Minutes, 14th Meeting

1. The draft minutes of the 14th Meeting of the Panel on Radiological Instruments held on 7-8 November 1955, are inclosed for your correction.

2. It is requested that any corrections be communicated to the Secretary, PRI, by 10 January 1956.

Hubert R. Smith

HUBERT R. SMITH
Capt., USAF
Secretary, Panel on
Radiological Instruments

1 Incl:
Cy of minutes
of 14th Mtg

Distribution:
Dr. G. Failla, Columbia University
Dr. W. F. Bale, Univ of Rochester
Dr. F. R. Shonka, St. Procopius College
Mr. T. E. Hedman, OChSigO, D/A
Major John d'H Hord, AFSWC
CDR E. C. Svendsen, BuShips

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M/R: Forwarding of draft minutes of the 14th meeting of the PRI to voting members for comment. All addressees have necessary clearance.

OFFICE SYMBOL	1. SWPRI	2. SWPEF	3. SWPSV	4. SWPG	5.
GRADE AND SURNAME OF COORDINATING OFFICERS	Capt Smith	A Kay	James J. Ney	[redacted]	

DRAFTER IDENTIFICATION: Capt. H.R. Smith crk 1B699B 74178
Rank or Grade Surname Initials of Typist Rm No Tel Ext
Prep 8 Nov 55

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MINUTES
FOURTEENTH MEETING OF THE
PANEL ON RADIOLOGICAL INSTRUMENTS

First Day - 7 November 1955

The meeting was called to order by the Chairman at 0920, with the following voting members present:

Dr. G. Failla - Chairman
Dr. William F. Bale
Dr. F. R. Shonka
Dr. R. A. Weiss - Army
CDR H. A. Jackson - Navy

The following alternates, associates, and other interested persons attended the meeting at the end of the Closed Session:

Mr. Robert O. Attmore	BuShips
Lt. Col. J. T. Brennan	AMSGS
Mr. Peter Brown	ESL
Mr. Robert L. Butenhoff	AEC
CDR F. W. Chambers	BuMed
Mr. Irving L. Cherrick	BuShips
Mr. Abraham Cohen	ESL
Mr. George Davis	NML
Mr. Frank Day	NBS
Mr. E. Di Ianni	NML
Capt. Duane L. Emerson	CONARC, Board #2
Mr. Irving Feister	DCS/O, USAF
Dr. Howard W. Gilbert	BuAer
Capt. James A. Graham	ESL
Mr. Jack C. Greene	FCDA
Mr. T. D. Hanscome	NRL
Mr. Toivo E. Hedman	OChSigO
Capt. Willis D. Holland	WRAMC
Maj. John d'H Hord	AFSWC
Dr. G. W. Imirie	NMRI
Mr. Martin Jachter	ESL
Mr. Joseph Lindwarm	CMLC Re & Engr Cmd
Mr. George W. Mahaffey	BuShips
Mr. Neil Marshall	NRDL
Col. Clinton S. Maupin	A/SGO
Capt. Ralph B. Neal	CMC
CDR J. A. O'Donoghue	BuMed
Lt. Col. M. R. Olson	CMC
Mr. A. Pfeiffer	BuShips
Mr. Irvin Plotkin	BuShips
Mr. Samuel C. Rainey	BuShips
Dr. W. J. Ramm	ESL
Dr. Arthur Redmond	NRDL

Declassified by DNA, Chief, ISTS, with exception of only.
DATE: 20 July 1994

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Mr. Edward R. Saunders	FCDA
Mr. Phillip Shapiro	ESL
Dr. Scott W. Smith	NBS
Maj. Jack Spencer	ARDC
Maj. Robert C. Spiker	OCAFF
CDR E. C. Svendsen	BuShips
Mr. Herbert Talkin	AEC
Mr. Gaylord Wall	NML
Mr. George Work	NRDL

For the Secretariat and sponsoring organization, the following persons were present:

LCDR Nathaniel I. Berlin	Dr. Frank Shelton
Capt. Thomas W. Connolly	Capt. Hubert R. Smith-Secretary
Lt. Col. George W. E. Daughtry	Maj. Roy C. Weidler
Capt. J. O. F. Dorsett	Maj. J. M. Wilson
Col. Eugene C. La Vier	YN1 Wallace E. Wolff
Col. Dent L. Lay	Miss Carole R. Karl
Lt. Col. Alfred H. Parthum, Jr.	

CLOSED SESSION:

A closed session was held from 0920 to 1000 hours. The first item to come before the Panel was the nomination of new members. New membership to the Panel resulted in a complete change of the Service membership. Nominations for the Navy, Air Force and Army members were read and brief biographical sketches of persons nominated for Panel membership were presented by the Service members and the Secretary. Following this the new members were voted on and their acceptance to the Panel was unanimous.

The minutes of the 13th Meeting of the Panel were reviewed and corrections suggested by the members were explained. The minutes were approved as corrected.

OPEN SESSION:

The newly accepted members, CDR Svendsen (Navy), Major Hord (Air Force) and Dr. Crenshaw (Army) sat as Panel members for the remainder of the meeting, except that Mr. Hedman (Army alternate) replaced Dr. Crenshaw, who was not present.

The Secretary addressed the conference and stated that the agenda included a review of weapons effects data which was of interest to the instrument people, but requested speakers not to stray too far from the business at hand and asked them to avoid the more sensitive areas, i.e., weapons employment and weapons design which were of no interest to the conference attendants.

Review of Weapons Effects Radiation Data:

Capt. T. W. Connolly of Headquarters, AFSWP, made this presentation. He gave as his chief source of information the "Capabilities of Atomic Weapons", TM 23-200, revised December 1954 and showed a chart indicating the test operations, past and future, which form the basis for our knowledge of weapons effects. The review covered the hazard of initial and residual gamma, and mention was made of the earlier concept of the lack of a neutron hazard. Mention was made of the large yield devices which were fired at CASTLE and the higher neutron flux weapons which have developed from recent advances in weapon design. Delivery rates and transport parameters of gamma and neutron radiation were discussed with the aid of two charts reproduced from the referenced TM, showing the percentage of total dosage of initial gamma radiation as a function of time for a 20 KT weapon at 1000 yards and for a 5 MT weapon at 2500 yards. The next chart presented showed the total initial radiation, gamma plus neutron, plotted as a function of range and yield. For total doses of 100 rem or greater, the neutron contribution was dominant at low yields and the gamma radiation was dominant at high yields. The relative importance of neutron and gamma doses was illustrated with the example of an M-48 tank at a scaled distance from various yield weapons where the tank crew had a 50% chance of survival based on blast effects alone. Only for yields in the megaton range was initial nuclear radiation not the dominant hazard to the tank crew.

A curve was presented showing fall-out contours for high yield weapons. The Naval Radiological Defense Laboratory (NRDL) work to determine the residual radiation spectrum was mentioned. This data is not yet available, but 60-90 kev may be the minimum energy of a residual field. A discussion of the beta hazard followed, during which it was stated that the AFSWP position at present was that the beta was the lesser of the residual hazards, and the results of the exposure of the Marshall Island natives seemed to indicate that the problem could be solved through training and use of protective clothing in the field.

Capt. Connolly then talked about the requirements for dosimeters suggesting there is a need for revision of our requirements for rate dependence and LD-50 concept. This was illustrated by showing delivery rates for initial gamma which indicated that under certain conditions the dosimeters recorded only about 75% of the total initial dose. This was followed by a general discussion on saturation of dosimeters and the need for response to dose rates of this magnitude.

Weapons Tests Gamma Measurements:

Capt. Graham, ESL, opened his presentation with a review of the origin of gamma which contributes to initial and residual fields. The importance of the hydrodynamic effect and the techniques used to

determine dose vs distance and dose rate vs distance measurements were given. Yield scaling was discussed and the transport equation for the hydrodynamic effect was given. This was followed by a description of the detectors used for total exposure vs distance measurements where film immulsion holders were used for doses of 1r to 30,000 r and the tests were mentioned from which the data had been obtained. There followed a description of the detectors used for determination of dose rate vs time and distance which included organic scintillators and unsaturated ion chambers.

Charts were shown which had dose rate vs time for surface and underground shots. Instrumentation was described, giving the time resolution and energy response of the instruments. Stilbene in graphite was used as the detector for 10 r per hour rates and higher and anthracene and graphite were used for rates of 1 mr/hr up. These had the over-all accuracy of 25%.

Weapons Tests Neutron Measurements:

Mr. Hanscome of NRL made the following presentation: Neutron flux measurements with some energy discrimination have been made at nearly all weapons tests. LASL, NRL, NRDL, and ORNL have participated, all using threshold and activation detectors such as gold (n,γ activation), sulfur, (n, p), neptunium 237 (n, f), uranium 238 (n, f), plutonium 239 (n, f), zirconium (n, 2n), iodine (n, 2n), arsenic (n,γ) and (n, 2n).

Whether these detectors provide a very accurate method for flux measurement, they have been widely used for lack of more precise and direct methods. The more useful detectors for effects work are gold (n,γ), slow-neutrons; Np 237 (n, f) threshold at 700 kev; U^{238} (n, f) threshold at 1.4 mev; Pu^{239} (n, f) shielded with B^{10}, thresholds at 200 ev, 1 kev and 4 kev for B^{10} shields 1 cm, 1.5 cm and 2 cm thick; and sulfur (n, p) threshold at 3 mev.

It has generally been conceded that neutron dose from atomic weapons is of secondary importance because the mean free path is small (about 200-300 yards), and because efficient weapons conserve internal flux at the expense of flux outside the weapon. Some weapons, however, lead to fluxes large enough to contribute substantially to the radiological dose. For the high altitude shot at TEAPOT approximately 50% of the dose could be ascribed to neutrons. For certain low neutron flux weapons in the 20-50 KT range detonated near the ground, neutrons contribute less than 10% of the dose in the critical region. Thus, neutron flux measurements are important for small yield weapons since lethal radiation extends into the region of survival from thermal air blast damage.

Correlation of Physical and Biological Data:

Colonel Maupin who had planned to present this report stated he had expected to base his presentation on the recent work of Dr. Payne Harris of Los Alamos who was forwarding the results of that work, but that the material had not reached Headquarters to date. Colonel Maupin added that since he did not have this more recent data, he preferred not to speak on the subject. The conference was advised that the dose of 675 r mentioned earlier in the meeting was a value that Dr. Harris was leaning toward as a result of a re-evaluation of the data available from the Japanese bombs. This value would probably be modified by as much as ±150 r. He also cautioned against complete reliance on the TEAPOT preliminary report by Dr. Harris (ITR-1167), advising that further analysis of the data had resulted in some revision of the conclusions.

Evaluation of Military Radiac on Operation Teapot - Army:

This was a presentation of the results of the TEAPOT Project 6.1.1a which were recorded in ITR-1137. Mr. Cohen reported on the evaluation of the DT-65 polaroid dosimeter, ElR-3 chemical dosimeter and the IM-93 quartz fiber dosimeter. Also, the report of the results of the evaluation of the IM-108 models XE-1 and XE-2 survey meter were given. The conclusions of the evaluation of the above instruments were read from ITR-1137 and possible causes of inaccuracies were mentioned. Details of the results of the TEAPOT project may be found in the above ITR (1137). Mr. Cohen's report was followed by a discussion of neutron sensitivities of the IM-93, chemical systems, and film badges, and the complexities of measuring neutron effects. There was also some discussion on the response of the IM-108 survey meter to X-band radar.

Review of Medical Projects:

Lt. Col. J. T. Brennan discussed the soft radiation problem and the beta radiation hazards. There was a general agreement on the matter of the soft radiation problem, but considerable disagreement and lack of knowledge on the relative importance of the beta hazard. The difference was pointed out between the beta contact hazard and the beta bath hazard. Emphasis was placed on the beta contact hazard by reference to the beta burns which have been recorded and the exposure of the Marshallese natives during the CASTLE operation.

A discussion of the difficulties attendant to measuring or detecting these point source betas followed, and he pointed out that the best solution seemed to be the avoidance of the hazard through "battlefield hygiene" and the use of sufficient body covering in order to avoid such exposure. The record has indicated that these protective measures would be adequate.

The work of Chambers, Imirie and Sharpe was referred to in which depth dose measurements within phantoms were made in residual radiation fields. The beta dose was received in outer tissue layers where the soft gamma component was of considerable significance. It was pointed out that the present practice had been to allow people to work in the residual fields (during test operations) using film badges to record

the total dose received. The lack of data to support a decision setting the tolerance level for the soft radiation components was mentioned. The discussion was concluded with the suggestion for the need of laboratory and field work involving exposure of large animals in order to determine the hazard of the soft radiation components of a residual field.

There followed a general discussion of the protection afforded by clothing and Lt. Col. Brennan noted that clothing did more than shield, but kept particles moving thus lessening point skin burns. It has been observed that the point type skin burns are usually of the order of 1/2 cm circles and are scattered over an area.

Median Lethal Dose for Man Exposed in a Radioactive Fall-out Field:

The presentation given by Dr. G. Failla was the following: When the armed forces undertook to develop military radiac instruments it was assumed that fall-out was not an important factor. The initial objective was to estimate the dose of prompt radiation received by a man. Since this radiation was known to be very penetrating, it was specified that the instrument should be reasonably independent of gamma ray energy down to 80 kev. (The neutron component was ignored). The choice of this figure no doubt was influenced by practical considerations, since it becomes increasingly more difficult to obtain energy independence below this energy level. This is particularly true of film badges, which at that time constituted the only practical dosimeter for field use.

While it is obvious that survey instruments would be used only in case of ground contamination due to radioactive fall-out or otherwise, the specification for energy independence in these instruments was the same as for dosimeters primarily intended to measure dose of prompt radiation. It was realized by many individuals familiar with the problem that something should be done to estimate the contribution to the dose received by a man in a fall-out field from beta rays and gamma ray components of lower energy than 80 kev.

I have always been of the opinion that what is needed for the evaluation of the biological hazard is a knowledge of the distribution of radiation in the human body, from the skin to the deeper tissues, no matter what type of radiation (beta or gamma) is responsible for it. For this reason I have urged that experiments be conducted in a fall-out field with suitably designed ionization chambers distributed in a phantom representing the human body. Such experiments were conducted in Nevada by CDR W. F. Chambers in 1953 and by Mr. Imirie in 1955. Owing to a number of circumstances the results are not completely satisfactory. Because of the practical importance of the problem it is desirable to make use of whatever information is available in order that at least some tentative conclusions may be reached.

The problem consists of two separate parts: (1) To decide what is the distribution of radiation in the human body in a fall-out field, in the light of presently available information. Since the information

is insufficient and the distribution must depend on numerous factors (nature of fall-out, terrain, position of the body, etc.) only a rough approximation can be made. (2) To estimate the biological hazard resulting from the assumed distribution of radiation in the body and thereby provide a figure for the median lethal dose for man thus exposed. Since there is practically no relevant information available, this estimate must be considered to be essentially a "guess".

Distribution of Radiation in the Main Portion of the Body of a Man Standing in a Large Fall-out Field: My best estimate at present is that this distribution is as shown in Figure 1. (See Appendix A).

(The distribution is slightly different from the one I showed at the January 1955 meeting of the Radiological Instrument Panel of AFSWP. The conclusions, however, are essentially the same.)

Estimation of Median Lethal Dose for Man when the Distribution of Radiation in the Body is as shown in Figure 1: In 1943 at the insistence of the Manhattan District Corps of Engineers it became necessary to assign a value to the median lethal dose for man. On the basis of some flimsy clinical data then available to me I suggested 500 r. All the radiologists consulted at that time agreed that this was a reasonable figure. Since then the dose has been variously quoted as being between 400 and 500 r. We may take 450 r for the present purpose.

Not much has been said about the point at which this dose is to be measured. My own conception at the time was that this represented the so-called "air dose" measured in free air at the point where the surface of the body would be, on the incidence side of a more or less parallel beam of penetrating x-rays (e.g. highly filtered 200 kv x-rays, corresponding approximately to monochromatic 100 kev gamma rays). The time of exposure envisaged was short. Under these conditions the depth dose distribution in the body is as shown in Figure 2. Assuming that the human body is 25 cm thick at the trunk, the dose in the center is about 50% of the entrance skin dose and the exit dose on the far side is about 25%. Accordingly, a considerable volume of tissue on the exit side receives much less radiation than the tissues on the entrance side. It is now known that in this case the radiation is not so damaging to the individual as a whole as when it is more uniformly distributed throughout the body. The experiments of Tullis et al[1] with hogs show that the $LD_{50/30}$ drops from 500 r to 350-400 r when the hogs are irradiated from two opposite sides. The difference might be somewhat greater if the animals were irradiated from all sides. We may assume, therefore, that a ratio of $\frac{350}{500}$ applies to man when the distribution of radiation in the body is nearly uniform. (Figure 2 is attached as Appendix B).

If the $LD_{50/30}$ for man is 450 r measured in air with a single beam of penetrating x-rays, we may assume that with backscatter the skin dose on the incidence side is 600 r. Making use of the above ratio we arrive at a dose of approximately 400 r within the body, when the radiation comes from all directions and its distribution in the body is nearly uniform.

The problem now is to estimate the median lethal dose (MLD) for man when the distribution of radiation is as shown in Figure 1. In this case the radiation enters the body from all directions and some is readily absorbed in the first 3 cm of tissue. The relative doses at pertinent depths are as follows:

Dose at	3 or more cm.	depth	100%
" "	1 cm.	"	150%
" "	5 mm.	"	250%
" "	1 mm.	"	750%
" "	7 mg/cm^2	"	1500%

If the uniform distribution of radiation in the central portion of the body extended to the surface, that is, if the high peak in the peripheral layer of tissue did not exist, the MLD would be 400 r measured within the body. Since from now on we shall talk about tissue doses and beta rays will be involved, it becomes necessary to express doses in rads. (The rad is the international unit of absorbed dose of ionizing radiation, equal to 100 ergs/gram). For the present purpose we may take 400 r of penetrating gamma rays as being equal to 400 rads. With a uniform distribution of radiation, death would be caused by damage of internal organs.

It is well known that destruction of a large fraction of the skin - by whatever means - causes death, also. It may be assumed that a dose of 4000 rads will cause permanent destruction of the human skin. Therefore a dose of 4000 rads, even if limited to the thickness of the skin, is lethal. Of course, in this case the lethal action of radiation is quite different from that of radiation uniformly distributed throughout the body. According to the above figures, if the dose in the central region of the body is 400 rads, the skin dose will be 6000 rads. Hence the man would receive a lethal body dose and more than a lethal skin dose. Experiments have shown that thermal burns of the skin decrease the MLD for animals exposed to gamma rays. Therefore, there is some interconnection between skin damage per se and the lethal action of gamma radiation in body doses that do not seriously injure the skin. Furthermore, the radiation in the case under consideration is not limited to the skin but extends to the deeper tissues, although the dose drops rapidly. Irradiation of a peripheral layer of tissue of considerable thickness, must influence the MLD. The problem is now to assess the contribution of damage in the skin and in this layer, to the lethal action of the radiation.

Table I

Animal	Baby Rats	Mice	Rats	Guinea Pigs	Rabbits
LD 50 Beta, Reps	2200*	4700*	7,500*	7,750*	17,500*
LD 50 Gamma, r	510	840	1,270	310	1,500
Ratio $\frac{\text{Beta}}{\text{Gamma}}$	4.3	5.6	5.9	25	11.7

* If expressed in rads these figures would be about 10% smaller.

Table I shows the results of animal experiments described in "Biological Effects of External Beta Radiation" by Zirkle and Lawson, N.N.E.S., Vol. IV-22E. (See Table 3.11, P. 74). The point of chief interest is the ratio of beta ray skin dose to gamma ray body dose for 50% mortality. Plastic plates impregnated with P^{32} were used as sources of beta rays - the entire body being exposed. The thickness of tissue effectively irradiated was about 3 mm. (Incidentally, the hair afforded considerable protection). In the smaller animals the layer of tissue thus irradiated constituted a larger proportion of the total body volume than in the larger animals. In this sense a peripheral layer of 3 mm in the rat might be considered to be equivalent to a layer of 3 cm in man. On this rather flimsy basis, the ratio between a surface dose of radiation limited to 3 mm depth in the rat and to 3 cm depth in man, and a uniform body dose of gamma rays, should be the same for rat and man. According to Table I this is 5.9. There is some justification for this assumption in that the ratio for smaller animals is somewhat smaller. The ratio for guinea pigs is completely out of line and may well be discarded. The ratio for rabbits is considerably higher.* There are two reasons for this:

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* The explanation given by the authors for the increase in ratio can hardly be justified in the light of present knowledge.

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(1) The thicker hair of rabbits probably absorbed more radiation, (2) A layer 3 mm thick constitutes a smaller proportion of the total body tissue of the rabbit.

Assuming that a ratio of 6 applies to the case under discussion,* the MLD

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* Note that this is not a ratio for beta rays and gamma rays, but a ratio for radiation (beta and soft gamma) that irradiates only the first 3 cm of tissue according to the dose distribution of Figure 1 and hard gamma radiation that irradiates the body essentially uniformly.

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when only the soft component of the radiation is present, should be 6 x 400 = 2400 rads, measured at the "surface". To conform with accepted practice we shall assume that a "surface" or skin dose means the dose in rads at a depth of 7 mg/cm^2. With the dose distribution of Figure 1 a skin dose of 2400 rads results in a body dose of 160 rads. This will contribute to the damage and therefore the MLD measured at the skin would be less than 2400 rads. Let us assume that 2000 rads over the entire skin and the concomitant internal body dose represents the MLD.

It is evident from the foregoing that the soft component of the radiation is the controlling factor, under the assumed conditions of exposure. A more realistic approach is to take into account absorption

of radiation by clothing. In doing this we may as well take into account, also, the variation of dose with height from ground. According to measurements by Imirie and Sharp, for a man standing in a fall-out field, the surface dose decreases by a factor of four from the skin to the top of the head, while the internal dose remains substantially constant.

The relative figures are as shown in Table II, taking the value at the height of the abdomen as 100%. (Interpolated by G. Failla).

Table II

Part of Body	Relative Surface Dose
Face	60
Chest	75
Abdomen	100
Knee	140
Shin	175
Foot	275

Let us assume that the entire body except the face is covered with clothing equal in absorptive power to 1 mm of tissue (100 mg/cm^2) and that the skin in the abdominal region receives 2000 rads through the clothing. Then the skin and internal doses are as shown in columns 3 and 4 of Table III. The integrated effect may still be too high so that this dose distribution may represent somewhat more than an MLD. On the other hand, clothing around the legs may well be thicker than 100 mg/cm^2, which will reduce the skin dose in these parts. (The feet need not be considered if heavy shoes are worn). Accepting this as the MLD distribution we must now reduce it to one figure. For this purpose we shall take the navel as the level of reference, which in the phantom man used by Imirie and Sharp was at a height of 115 cm. At this level the skin dose through 100 mg/cm^2 is 2000 rads and the internal dose is 267 rads. This must now be correlated with an instrument reading at this level.

Table III

1	2	3	4	5	6	7
Part of Body	Absorber mg/cm^2	Dose in Rads				
		Skin	Internal	At Surface of Clothing	Through 500mg/cm^2	Through 1000mg/cm^2
Face	(7)	2400	160	2400	400	240
Chest	100	1500	200	3000	500	300
Abdomen	100	2000	267	4000	670	400
Knee	100	2800	370	5600	930	560
Shin	100	3500	470	7000	1170	700

Assuming that the instrument is a tissue equivalent ionization chamber with 2π geometry and is held against the body to provide the necessary

backing, the figures in columns 5, 6, and 7 of Table III represent the reading for the MLD when the hemispherical wall of the chamber is respectively 7 mg/cm^2, 500 mg/cm^2 or 1000 mg/cm^2. Most military instruments have walls in the range of 500 to 1000 mg/cm^2 and, therefore, if properly designed and calibrated, a reading of about 500 r at the level of the navel represents a median lethal dose for man in a fall-out field. It is important to note that under these conditions the dose at depths greater than 3 cm should not exceed about 250 rads.

It is very surprising to find that with all the assumptions and allowances made here, we come out with essentially the instrument reading used heretofore as representing an MLD. This is a mere coincidence and does not justify in any way the assumptions made. The problem should be analyzed by others, using other approaches. It may then be possible to arrive at a more reliable estimate.

Response of Radiac Instruments in Residual Fields - Navy:

The results of Operation TEAPOT Project 6.1.2 were presented by Mr. G. Work of NRDL. Conclusions presented remain essentially the same as those reported in the preliminary project report (ITR-1138) on accuracy of military radiacs. Mr. Work discussed the directional and energy dependence factors effecting radiac accuracy, field source characteristics, and design considerations for the field standard instrument as well as the methods used to determine radiac errors in field conditions. In general, military radiac instruments read low in field conditions even though carefully calibrated and carefully handled. The standard instrument used in this field work was the 100 mr Victoreen thimble chamber shielded with 1500 mg/cm^2 plastic to eliminate the beta dose. A technique of "off" calibrating instruments to reduce reading errors was mentioned, and organic phospher used to measure the contributions of the distributed field was described.

The above report was followed by a discussion of the techniques of measuring residual fields with survey meters and the suggestion was made by Dr. Failla that possibly our field instruments were more accurate than indicated based upon the results of depth dose measurements made concurrently.

Military Requirements - Army:

Major Spiker opened his presentation by briefly describing the development and test organization within CONARC and mentioning the procedures by which military characteristics and standardization of instruments are determined. Major Spiker presented what CONARC believed to be the Army requirements for military radiac.

There is a requirement for a self-reading tactical dosimeter and this requirement was set forth several years ago by CONARC. The expected use of this dosimeter was to be by commanders of small units

as a guide in determining the amount of gamma radiation received by the men of the command. It was not expected that the tactical dosimeter would provide information on the amount of radiation received by the individual soldiers, but rather that the dosimeter would provide an indication of the total gamma dosage received so an estimate of mass exposure could be made and tactical plans adjusted accordingly. The readings can be used as a basis for controlling exposure of units by indicating when continued exposure should be avoided. In this way, the commander can make optimum use of his troop units based on past radiation exposure.

The several types of dosimeters which had been developed to meet the requirements were reviewed. The DT-65 film badge, the ElR-3 and the IM-93 were mentioned. Extensive tests of these dosimeters by CONARC Board No. 2 resulted in a recommendation that the IM-93 be standardized and no further effort be expended on the DT-65 or ElR-3. The most apparent drawback to the IM-93 is the requirement for a separate charging device which has not been standardized for use at the present time. The PP-995 submitted to fulfill that requirement was available, but many deficiencies were noted and the charger is being modified. Winter tests of the IM-93 will be conducted to determine its suitability for use in extreme cold and the present basis of issue for the IM-93 is one to each platoon or unit of comparable size. Although Board No. 2 had recommended no further consideration of the ElR-3 as a tactical dosimeter, the reports on chemical systems used in Operation TEAPOT had been studied with considerable interest by CONARC. Of particular interest was the data on neutron sensitivity of the various chemical systems. Although the actual biological significance of neutrons was not well known, nor the percentage of neutrons and gammas received in an situation, it is probable that CONARC would state a requirement for at least feasibility studies leading to the development of neutron dosimetry in the near future.

In addition to the requirement for tactical dosimeters, CONARC has a requirement for a technical dosimeter for use in mobile radiological laboratories by decontamination units, and the IM-20, a 0-50r version of the IM-93, is presently under test. Preliminary results indicate the IM-20 will meet this requirement. The matter of providing an administrative dosimeter is still not settled. However, the Surgeon General has not stated a requirement for exact exposure records and this problem is still under study.

The Army foresees a requirement for two, and possibly three, types of dose rate meters. The first requirement is for a tactical survey instrument. This instrument must be light, rugged, reliable, and easily read. It will be used by combat units to detect and measure areas on contamination that are potentially dangerous to the unit. This instrument will be distributed at least to battalion level and probably to company level. The IM-108 survey instruments have been tested by Board No. 2 and appear to satisfy this requirement. They read from 1 to 500 r/hr on a logarithmic scale. While the report of the test has not been received by CONARC, it appears that the L-shaped IM-108 will be recommended for standardization.

The report by Board No. 1, CONARC, of December 1953, did not indicate a requirement for a contamination meter to measure low intensities of gamma radiation. However, more recent study has indicated certain special cases in which the contamination meter is necessary. The contamination meter will be used by medical units to determine contamination of wounded personnel prior to treatment. It may also be used by engineer water points, Quartermaster bath and laundry units, and by radiological monitors at all echelons. It is considered necessary that the contamination meter detect injurious amounts of contamination in fairly heavy gamma background fields. Therefore, a beta detection capability will be required. The instrument must also be rugged, reliable and usable as a survey instrument when necessary. The IM-70, currently under development, appears to fulfill most Army requirements except for the beta requirement. Upon completion of a Board No. 2 study of this problem, it is expected that a modification to the IM-70 will be requested to permit beta detection in a gamma field not exceeding 1 r/hr.

A study is currently under way to determine the feasibility of rapid aerial survey and it is thought that it may be necessary to provide a special instrument with greater sensitivity to accomplish such a mission.

Military Requirements - Navy:

CDR Svendsen presented the Navy requirements for radiac and distributed a list of the Naval requirements which is attached as Appendix C. The requirements and the equipment designed to meet these requirements was more or less standardized and although developed some time ago, still appeared good to the Navy and no change was contemplated until evidence clearly indicated revision was necessary. The newer group of requirements currently receiving attention in the Navy are listed on the second sheet of the attached Appendix C and these are the special requirements for instrumentation for nuclear powered ships which cannot be met by standard equipment. A third group of requirements was presented which included those items for which detailed characteristics have not been formulated. These new requirements are:

1. Neutron dosimeter, high range.

2. Fixed detector, remote indication monitoring system for shipboard installation.

3. Beta contamination meter.

4. Underwater dosimeter.
5. Underwater survey meter.

} for underwater salvage or demolition work.

6. Training equipment (simulated).

7. Accessory equipment for use with standard equipment:

a. Emergency air sampler for use with PDR-27.

b. Emergency water sampler for use with PDR-27.

c. Battery operated reader for DT-60 dosimeter.

Most of these items are in the R&D stage either in Naval laboratories or under development contract. Another group of requirements for Navy airborne equipment was presented by Dr. Gilbert of BuAer. (See Page 22).

Military Requirements - Air Force:

Air Force requirements were given by Major Nord who gave first the requirement for a special instrument for measurements while flying through the atomic cloud. Such an instrument is being developed by the Signal Corps and will be designated the IM-111 (referred to as the Bio-Scel). The instrument is an ion chamber having a range of from 1 r/hr to 2000 r/hr. There is a similar instrument under development by the Kaiser Aircraft Company which records on a wire recorder and has a range of from 1 r/hr to 1000 r/hr. The use of Bendix dosimeters in test operations and Air Force requirements which have been filled by standardized instruments were mentioned. These included the DT-60 (an administrative dosimeter) and the CP-995 reader, the PDR-27, PDR-39 and IM-70 survey meters and the PDR-10 alpha meter. There are additional requirements for a 5 r dosimeter for aircraft and a fixed instrument to be located at airfields and weather stations. The fixed instrument should be capable of reading at very high rates for a determination of fall-out distribution in the event of an all out attack. Another instrument, a quartz fiber rate meter (500 r/hr device), will be tested at the next weapons test. The main difficulty with such an instrument is the time constant which is on the order of 7 seconds. The instrument features a meter which indicates the current flow through a resistor in series with the ionization chamber and condenser.

Military Dosimetry - Where To? - Navy:

Mr. Rainey ennumerated the uses of, and requirements for, military dosimeters, which are:

1. To furnish military tactical information.

2. To furnish medical information.

3. To furnish administrative information.

4. To monitor personnel in low level and high level fields.

5. To furnish a psychological bulwurk against a new and mysterious phenomena.

6. Furnish radiation effects information upon which future doctrines can be based.

Five reasons why dosimeters may not read properly or give the desired results are:

1. Unexpected type of radiation.

2. Poor design criteria.

3. Mechanical Failure.

4. Misunderstanding of the biological effect.

5. Poor dissemination of the information required for their use.

The importance of determining the characteristics of most types of radiation and the necessity of thorough field testing were stressed.

Discussion on Military Requirements:

During the discussion of military requirements, the speakers who had presented the service requirements took the stand, beginning with Major Spiker who answered questions from the audience. In answer to these questions, Major Spiker indicated the Army was more satisfied with the available instruments and the opinion was that the IM-93 would fill tactical requirements. Although the EIR-3 did not meet the requirements, the chemical systems were still of interest to the Army from the standpoint of neutron dosimetry. There followed a discussion of the requirement for the logarithmic scale and the weight and size of survey instruments as well as the accuracy requirements of survey instruments. Concerning accuracy requirements, Major Spiker advised that he felt more accuracy was desirable in the range up to 100 r/hr than the range above 100 r/hr.

CDR Svendsen took the stand and stated that the Navy was very much interested in the neutron dosimeter problem and felt an urgent need for a better determination of the response of their standard dosimeters. He also indicated the Navy was doing some work on a fixed monitoring device for a ship. The Navy feels no change is needed in the limit scale of radiac (from 200 r to 600 r).

Major Hord followed with general comments on the Air Force requirements, indicating a need for an administrative dosimeter and he added that they would like to have a neutron dosimetry capability. He also stated there was, in general, concurrance in the Air Force on the need for a beta probe.

Second Day - 8 November 1955

Tripartite Conference - Army:

The report of the CBR Tripartite Conference held during September in Ottawa and attended by the representatives of the United States,

United Kingdom and Canada was made by Mr. Lindwarm of the Army Chemical Center. Mr. Lindwarm briefly outlined the purposes of the conference. He reported the scope of the meetings follows broadly the areas of detection, protection and decontamination with some discussion of phenomenology.

Most of the results of the Tripartite Conference were covered by previous reports given at the 14th PRI. The various areas covered, however, were:

1. Beta hazard was discussed and the U.S. made a major contribution to these talks. Accidental exposure of natives at CASTLE was discussed. Emphasis was on the bio-medical aspects. The U. S. contribution from NMRI at TEAPOT on phantoms was discussed and the United Kingdom representatives indicated that the results of NMRI were about the same as the U.K. results. The U.K. attributed the surface dose to beta rays. NMRI did not make this distinction between the beta and soft gamma.

2. In this particular regard the U.K. feels that in spite of CASTLE-BRAVO shot results where there was no indication of beta body phenomenology, it is still something to be contended with and the 10 to 1 ratio is a worry. In instrument development the U.K. wants a determination as to whether we do or do not get a 10 to 1 ratio.

During a discussion at the conference on the physical significance of low energy component of a gamma spectrum, the U.K. indicated that they felt there was no significant contribution below 60-70 kev. It was reported that Dr. Taylor (of the U.K.) is studying the use of their survey meter number 2 - an ion chamber - to discriminate between beta and gamma. It was felt that beta gamma ratios of less than 10 to 1 would not constitute a whole body hazard in which case the beta contribution could be neglected. Their calculations of the beta hazard are based on a consideration that clothing thickness is of the order of 50 mg/cm^2.

The U.K. raised a point about radar interference on radiac instruments. They were also interested in the techniques used for monitoring water and had looked into the use of the survey meter number 2 for monitoring food and personnel. All three countries now have radiac instruments which are either standardized or on an advanced stage of development, therefore, some exchange of instruments was recommended.

As a result of the Tripartite Conference, these recommendations were made:

1. That some re-determination of the LD-50 mid-line dose be made.

2. Suggested that LD-50 from initial radiation might be revised upward and that LD-50 from residual radiation might require revision downward.

3. Recommendation of the physiological significance be studied for gamma energies between 90 and 30 kev.

4. That all three countries undertake an exchange of radiac equipment.

Neutron Survey Equipment - Navy:

Dr. Redmond exhibited a neutron survey meter which is presently in development at NRDL. This instrument was shown at the 13th meeting of the Panel and the use of the instrument was briefly outlined in the minutes of that meeting. Some changes have been made, one of them being the use of a transistor power supply in the new models. The instrument uses two proportional counters and another modification was the use of methane only in the chamber which had previously used methane and hydrogen. It was found that the hydrogen was hard to contain. The instrument is used in connection with charts showing an assumed moderated or unmoderated neutron spectrum. The proper curve is selected by taking count rate measurements at two discriminator settings which then permits the calculations of the actual dose rate by use of the meter reading and the curve. The instrument is biased at 1 r per hour to eliminate gamma contributions.

Standardization of Dosimeters - Army, Navy and Air Force:

A report was requested on the standardization of dosimeters, recommended by the 13th meeting of the PRI. There was some general discussion on the subject of standardization of dosimeters during which the service members re-stated their requirements as given earlier in the meeting. No further recommendations were made. There was also some discussion on procurement methods and Mr. Cohen reported that the specifications of the IM-93 contract were performance specifications.

Use of PDR-27 to Monitor Water - Navy:

The results of a recommendation of the last PRI to determine the capability of the PDR-27 for water monitoring were given by Mr. Attmore of NRDL. The PDR-27 has been found to be suitable for water monitoring. Results obtained from both NRDL and NML indicate direct measurement of a 3 micro curie per liter Strontium 90 solution will give a background corrected reading of approximately 0.12 mr/hr on the AN/PDR-27 series radiac set. The normal background observed was about .02 - .03 mr/hr. These readings were made with the window open at the distance of about 1 cm from the surface of the sample giving approximately a one quarter scale reading on the most sensitive scale.

In the case of water contaminated with fission products, NRDL has obtained direct readings on the AN/PDR-27 equivalent to 0.05 mr/hr for 1 day old fission products, and to 0.12 mr/hr for 20 day old fission

products, both for concentrations of about 3 mc/l. Consequently, the AN/PDR-27 may be used to monitor water on a 10 day emergency basis when the contamination is produced by fission products. In the case of 1 day old products, however, the background must be fairly low.

The effective sensitivity for water monitoring can be increased by a factor of 100 or more by the filtering of the water through a millipore or other efficient filter. By using filtering two advantages are obtained:

1. Concentrations much lower than the 10 day emergency level can be detected, and;

2. The measurements can be made in a fairly high background. One half liter to a liter is required. Filtering takes approximately 20 minutes per half liter.

Status Report of Navy Hi-Range Survey Meter - Navy:

Mr. Cherrick reported the survey instruments which had been evaluated by the Navy. These included two instruments manufactured by Anton, the Army IM-108, and the NRDL instrument designated the RGI-18. This evaluation was made by NRDL, NML, NRL and NBS. On the basis of the evaluation, it was concluded that the two best instruments were the commercially developed EP-501 and the NRDL RGI-18. A primary criteria for selection was the readability and accuracy in the range 100 to 500 r/hr. Other factors considered were energy dependence, battery life of 40 hours, calibration and zero drift. Reports of evaluation are available at BuShips.

Status Report of Beta Survey Meter - Navy:

Mr. Marshall reported on the development of a beta survey meter (as yet undesignated) which would feature a gamma signal rejection such that 100 millirep/hr beta surface dose rates will be indicated with less than 10% full scale error when the detector in ambient gamma flux of 0.1 r/hr. The following beta surface dose rate ranges are to be incorporated: 0-500, 0-5,000, 0-50,000, and 0-500,000 millirep/hr. The instrument will also feature an air ionization chamber hermetically sealed. The sensitive volume and window thickness will be such that the indicated beta surface dose rate within the over-all uncertainties of the system in the method is biologically accurate.

A prototype model of the AN/PDR-44(XN) was displayed. This instrument has a linear scale and multi-range presentation and features a balanced electrometer circuit using a militarized version of the 5884. Gamma detection is accomplished by a dome shaped ion chamber having a 2π geometry and a covering of lead filter plates. The chamber is xenon filled and has an energy response flat down to about 80 kev. Beta detection is accomplished with an

air filled ion chamber with a 10 mg/cm^2 window and the beta detection is such that the threshold or tolerance dose of 50 rep/hr results in a mid scale reading. The beta detection chamber also responds to the low energy gamma which is not read on the hi-energy gamma chamber. The "beta" chamber response to high energy gamma (about 80 kev) is down by a factor of about 20. The operator using this instrument selects the "beta" or "gamma" chamber by the use of a switch. The instrument features a transistor power supply and 1½ volt flashlight cell. The meter used is a ruggedized 20 micro amp meter with a time constant of under one second.

Status Reports of PDR-17XN4 and CP-263 Reader - Navy:

Mr. Rainey reported that the CP-263/PD portable reader for the DT-60 is now in the service test stage, and complete tests have not been made. A prototype production model was demonstrated which was powered by a vibrator power supply and 5 flashlight cells. The battery life was given as about 40 hours. The flash bulb used was a Sylvania S-698 and pulse length was about 50 microseconds. The response of the reader to the pre-dose reading of the DT-60 was about 2 r and the minimum reading which could be read on the CP-263 was about 10 r. The weight of this reader is about 9 pounds. Fifteen of these readers have been ordered for service test and delivery is expected within the next 8 months.

Another instrument was then displayed, an AN/PDR-17XN4, which consisted of a housing with built in dosimeter charger designed to receive an IM-107 quartz fiber dosimeter, or similar type. The charger consisted of a lucite rotor and teflon pad. Voltage regulation was accomplished by the use of a gas tube to limit the charge to 200 volts. This instrument was now on service test contract to Chatham Electronics and procurement of 200 had been initiated. Estimated cost is about $30.00 each for the assembly.

Status Report of IM-111 and IM-106 - Army:

This status report of the IM-111 and IM-106 was made by Mr. Jachter. The radiac meter, IM-106, which was described, was tested during Operation TEAPOT in the spring, but the results of the test were not yet available. This instrument, shown to the conference attendants, was reported also at the 13th meeting of the PRI. The instrument is designed to be mounted in an aircraft instrument panel and has a cylindrical shape. The circuitry is quite similar to that used in the IM-108. The range of 50 mr/hr to 500 r/hr is presented on a logarithmic scale.

Mr. Jachter then demonstrated the IM-111, also an instrument developed for use in aircraft. The instrument is designed in two units for instrument panel mounting and the scale ranges from 1 r/hr to 2000 r/hr. The use of the instrument is for measurements within an atomic cloud. The instrument was developed at the request of

AFSWC and was required to operate in a wide range of temperature, pressure and humidity conditions, as well as to be energy independent for gamma energies between 80 kev and 1.3 mev. Mercury cells are used and heating for the cells is provided by a heating element and thermostat using aircraft power in order to overcome the low temperature effects (-20°F) on mercury cells.

Procurement had been initiated for 20 of these instruments which will be supplied to AFSWC. A 1% meter movement will also be used which is expected to give a probable accuracy of ±20%.

Status Report of IM-93 and PP-995 - Army:

Mr. Cohen reported that procurement of the IM-93 had been initiated and 55,000 units were expected to be available by July of 1956. This had been done by contract to the Landsverk Instrument Company at a bid of $7.90 each.

The status of the PP-995 was reported to be still in the R&D stages as had been mentioned earlier in the meeting. The charger tested on Operation TEAPOT was in need of several modifications which were now being undertaken. Two instrument designs are in process, one having the form factor of a flashlight case. A production contract for the PP-995 is expected before 1 July 1956.

Status Report of IM-108 and IM-70 - Army:

Modifications to the IM-108 subsequent to Operation TEAPOT were reported by Mr. Jachter. The instruments obtained for service test were evaluated on Operation TEAPOT, at NBS and at the Signal Corps laboratory. Slides were shown indicating the deficiencies observed. Reference was made to the evaluation report by the National Bureau of Standards (Report #4088) and conclusions of that report were read. Based on the TEAPOT and NBS evaluation, the laboratory had requested the following modifications:

1. Re-work of the battery compartment.

2. Re-work of the gasketing.

3. Addition of a check circuit.

4. Modifications to permit calibration adjustments from an external port.

The instrument models were submitted to CONARC for test at BIG DELTA and are being re-submitted for physical and environmental testing.

The radiac meter, IM-70, is in production under a development contract. The IM-70 was described at the 13th meeting of the Panel of Radiological Instruments and has been known popularly as "Jake".

Delays in production occurred because the first model failed the low pressure testing of the chamber. Also the battery contacts required modification.

Following Mr. Jachter's report, there was considerable discussion on the use of logarithmic scales and the meter accuracy inherent to such presentations.

Statistical Basis for Accuracy and Precision Requirements for Dosimeters and Survey Meters - Army:

Mr. Cohen made this presentation and discussed the accuracy of logarithmic instrument compared to standard instruments. From such a comparison Mr. Cohen concluded that a specified accuracy of $\pm 30\%$ for 95% of a production run can be met by the present state of the art. The statistical basis for accuracy and precision requirements for dosimeters was given. The military characteristics specified for step reading dosimeters were discussed and a statistical formula which is applicable to obtaining the estimates of the true mean in a variable radiation field was given as:

$$\frac{\sigma_1^2}{\sigma_2^2} = \frac{n_1}{n_2}$$

This is specifically intended to indicate the relative quantities of coarse or fine instruments required to give the same information to tactical commanders. For example, the average reading of five instruments with 10% accuracy will be as good an estimate of the true mean as the average reading of forty-five (45) instrument with 30% accuracy.

Monitoring Equipment for Nuclear Power Equipment - NML:

Mr. Wall presented the first portion of this report. In addition to the radiation hazards of land based reactors, the problems arising from the lack of space and lack of ventilation on a submarine make accurate and reliable radiation detection on board a nuclear powered submarine very important. Generally, there are 2 facilities for safeguarding crew members from this danger. First, a system of fixed detectors that measure radiation levels at critical locations and automatically sound alarms when excesses occur. Secondly, a complement of portable gamma, beta and alpha survey meters operated by health physics personnel. In the former, GM tubes for gamma and beta and proportional counters for neutrons send pulses to computer-indicator circuits which in turn display radiation level information on log rate meters. The same signal trips an alarm when certain preset levels are exceeded. The detectors are grouped around the reactor and auxillary equipment at critical points. In the second facility, standard Navy field

survey instruments are finding general acceptance. There is a need for a beta-gamma survey meter with an extended probe for surveying conditions peculiar to a reactor.

Following Mr. Wall, Mr. Di Ianni gave a presentation as follows: On the basis of theoretical and experimental studies, the NML has developed techniques and procedures to be used on board the Nautilus and other nuclear powered craft for measuring beta-activity in water. Two separate procedures have been developed, one for monitoring, the primary coolant of the submarine reactor, the other for monitoring the drinking water used on board. In the first procedure, in which a conventional end mica window Geiger-Mueller tube is utilized as the detecting element, samples of the primary water coolant, having beta concentrations in the range 5×10^{-5} to 100 mc/cc, can be measured directly or after dilution with uncontaminated water. In the second procedure which utilizes a flat cylindrically shaped Geiger-Mueller tube with a mica window on each end as the detecting element, samples of the drinking water are evaporated to dryness prior to counting to enable measurement of concentrations as low as 10^{-7} mc/ml.

A second detection device designed by the Laboratory to monitor the activity of radioactive Argon 41 in the atmosphere of the Nautilus has been recently incorporated into the complement of monitoring equipment on the Nautilus. The instrument enables collection of air samples throughout the submarine, and utilizes the detection and counting components of the AN/UDA-1 Water Monitor. Using this technique concentrations as low as 10^{-6} microcuries of Argon 41 in air may be measured with reasonable accuracy.

Airborne Radiac - Navy:

The Bureau of Aeronautics' presentation on the status of airborne radiac equipment was given by Dr. Gilbert. The AN/ADR-1 gamma radiation indicator has been used in weapons tests operations since GREENHOUSE to measure gamma radiation in both manned and unmanned aircraft. The instrument has a range of from 0 to 200 r in two scales which charge automatically. The instrument can be used with the RD-77 recorder.

The AN/ADR-2 dosimeter was also mentioned. This unit had serious temperature drifts, but work was discontinued as the requirements for such an instrument were met by the AN/ADR-1.

The AN/ADR-3 radiation cloud tracker is used in aircraft to distinguish between atomic and normal clouds illuminated by sunlight.

A ground survey instrument, the AN/ADR-4, is currently being re-packaged and revised as an externally carried unit for use in cloud and ground survey measurements. When this instrument is used as a ground survey instrument the data is recorded along with corrections for altitude and air attenuation. The scale of the instrument ranges from 50 mr/hr to 5000 r/hr.

The AN/ADR-5 gamma indicator, a small unit for giving indications of 5 mr to 80 mr gamma fields, was described. Its use is as a pilot protection system on aircraft.

Two other devices, the AN/USQ-1 and AN/ARR-29(XN-3) gamma telemetering transmitter and receiver, are in development test. This equipment provides a transmitting range of over 100 miles with interconnection to the aircraft radar for azimuth location. The major problem found in tests was leakage of water into the case. This is being remedied by minor redesign of the battery compartment seal. The range of indication is 50 mr/hr to 2000 r/hr with possible extension by extrapolation, with less accuracy, to 5000 r. Data transmitted may be for 6 to 8 hours. This equipment was tested during Operations CASTLE and WIGWAM in connection with other projects.

Radiac Flares were next described. These are small droppable units which indicate if 5 r/hr, 50 r/hr and 500 r/hr are exceeded. Only one range is included in each unit. These are intended for dropping to indicate conditions at various points. They have the advantage that they are cheap and do not require special servicing and they can be used by personnel who have had no specialized training.

CLOSED SESSION:

After hearing all the briefings, the Panel met in closed session to consider recommendations on subjects of interest which had been supplied to the Panel members. There was a brief discussion on the requirement for neutron dosimetry and the following resolution was unanimously voted by the Panel:

> There is a requirement for neutron dosimetry and the Panel recommends that a feasibility study be made to determine the application of physical principles to military dosimeters. The Panel also recommends the AFSWP fund such a study if necessary.

The Panel had been asked what physical principle might show promise of fulfillment of military requirements for total dosimetry but they could not make any recommendation at this time although there was general agreement that the problem was probably not as difficult as it appeared and that the development of tissue equivalent ionization chambers might be worthwhile.

There was a discussion on the design of experiments for future weapons tests projects on radiac evaluation which resulted in the folllowing unanimous recommendation from the Panel:

> That some comparison of military dosimeters with say, Sievert type of chambers distributed in a phantom, be done in connection with residual fields from weapons tests.

The response of dosimeters for initial radiation was also discussed and the Panel made the informal recommendation that experiments be conducted to determine the response of ion chamber instruments to high dose rates so that a correlation of response to initial and residual radiation might be obtained.

A discussion followed on the correlation of instrument read dosage to human damage which resulted in the following unanimous recommendation from the Panel:

> The Panel recommends the exposure of large animals such as pigs in a residual field strong enough to produce 30 day lethality.

The Panel then considered military requirements for radiac. Although no formal recommendation was made, it was generally agreed that presently accepted requirements for rate and energy dependence are adequate and realistic, but these requirements should be subject to further evaluation.

The meeting was concluded at 1830 hours. Although there was no date set for the next meeting, the matter of a special meeting to consider results of medical studies was discussed. A meeting date was suggested for early in February or March 1956.

Hubert R. Smith
HUBERT R. SMITH
Capt., USAF
Secretary, Panel on
Radiological Instruments

3 Incl:
Appendix A
Appendix B
Appendix C

(NOTE: Appendices A and B are not available at the present time, but will be added to the final minutes.)

Requirements for Navy Military Radiac Equipments

Function	Range	Standard now available	Standard under development or procurement	Remarks
Dosimeter, Low range Self Indicating (Technical)	0-200 mr	IM-9()/PD (A) thru (D)		
Dosimeter, High range, Self Indicating (Tactical)	0-200 R		IM-107/PD	Service Test Completed
Dosimeter, High range, Self Indicating (Administrative)	0-600 R	DT-60()/PD		
Dosimeter, alarm	0-200 R		AN/PDR-31	Preproduction Models of Ser Test Complete
Dosimeter charger for Technical or Tactical Dosimeter	---	PP-354C/PD		
Dosimeter reader for Administrative Dosimeter	0-600 R 0-200 R	CP-95/PD		
Survey meter, High Range Gamma measuring, Beta indicating	5-500 R/hr	AN/PDR-18() (A) and (B) (Interim Standard)	AN/PDR-43 AN/PDR-44	Under Service Test Procurement
Survey Meter, Low Range Gamma measuring, Beta indicating	0-500 mr/hr	AN/PDR-27() (A) thru (H)		
Survey Meter, Alpha	0-10,000 disintegrations per minute per 150 sq. cm.	AN/PDR-10() (A) thru (D)		Energy Range 4 to 5 MEV

Requirements for Navy Nuclear Power Radiac Equipments

Function	Range	Currently in use	Standard under development	Remarks
Survey Meter, High range Beta Gamma, Probe Type	.5-500R/hr	---	AN/PDR-43 - with probe	Equipment to be same as High Range Standard survey equipment except for probe
Survey Meter, Neutron	0-1000 mrem/hr	AN/PDR-42(XN-1) and Rudolph	D-2X (Tracerlab)	Energy range .025 ev to 10 mev
Dosimeter, Low range Neutron	0-600 mrem	IM-112/PD (Model L-29)	Lab development	Energy range .025 ev to 10 mev
Scaler	---	CP-79/UD or NICC Model 183	Militarized model of 183	
Assay Accessory Group	---	AN/UDA-1	Militarized model	Detectors and accessories used with scaler to determine contamination in coolants, potable water, surfaces (wipes)

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	CHIEF, WPNS DEV						
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