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ARMED FORCES SPECIAL WEAPONS PROJECT
WASHINGTON, D. C.

3 September 1953

SWPEF-6/923

SUBJECT: Analysis of Biomedical Weapons Effects

TO: Captain H.H.Haight, USN
Division of Military Applications
U.S.Atomic Energy Commission
1901 Constitution Avenue, N.W.
Washington 25, D.C.

1. In accordance with the AFSWP letter to the Services and other interested agencies, subject: "Analysis of Atomic Weapons Effects Program", dated 2[illegible] March 1953, the inclosed information has been prepared. This data, relating to the current status of knowledge in the medical and personnel effects of atomic weapons, is specifically directed toward operational requirements. Certain medical aspects, such as therapeutic problems, have not been discussed as they are outside the scope of this study.

2. The conclusions and recommendations made in the study represent the opinion of the AFSWP. No elaboration is attempted. Definite statements are made on which to base discussion at the conference scheduled for 10 September 1953 at Headquarters, AFSWP, Washington, D. C. Members of the Effects Division will present the current knowledge of basic physical measurements at the conference.

3. It is requested that the inclosures be reviewed so that these and any problems that may have been omitted can be evaluated by the technical representatives at the conference with the objective of:

a. Definitely establishing those fields of weapons effects in which sufficient information for operational needs is available and for which additional full scale test or R and D laboratory projects are not required.

b. Definitely establishing a minimum requirement for additional full scale tests or R and D laboratory projects to fulfill operational needs.

4. The conclusions of the scheduled conference will be incorporated in an overall effects analysis study.

BY COMMAND OF MAJOR GENERAL LUEDECKE:

5 Inclosures:
1 Biomedical Air Blast Injuries, Direct
2 Biomedical Thermal Effects
3 Thermal Effects on the Eye
4 Radiological Hazards from an ABD, Alpha, Beta and Gamma Radiation
5 Radiological Hazards from An ABD, Neutrons

H. H. Rankin
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Adjutant General

CLASSIFICATION CANCELLED
BY AUTHORITY OF DOE/OC, DNA Ltr 6/14/84
REVIEWED BY [illegible] DATE [illegible]

[redacted] in part is prohibited [redacted] Chief, AFSWP.

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ATOMIC ENERGY ACT 1946

MRA 3 LRD

SUBJECT: Biomedical Air Blast Injuries, Direct

OBJECTIVE: To determine the effects of direct air blast on animals.

TEST PROCEDURE: A number of different methods for exposure of animals have been attempted including simple mesh cages, sliding cages, open end aluminum cylinders, and foxholes. The various methods, with the exception of foxholes, were designed so as to shield the animals from secondary blast effects (missiles), thermal radiation and some of the nuclear radiation. None of the containers have been entirely satisfactory.

STATUS OF KNOWLEDGE: The complex problem of effects of direct blast resulting from atomic detonation has not been solved; however, based on direct physical measurements of blast, extensive laboratory high explosive studies, some human experience during the bombing of London during World War II and the work done in Europe during the last ten years, it is generally agreed that direct blast is not an important cause of atomic weapons casualty production. Under unusual circumstances, i.e. certain types of shelters, direct blast might be the primary cause of casualties.

Zuckerman states that the lethal blast range for humans exposed to HE detonations is in excess of 350 psi although some of the above data suggest that the longer blast duration of ABD blast waves may have a different effect. Anatomical damage can be done at much lower psi levels. The range of damage to eardrums is in the order of seven to twelve psi. Minute internal hemorrhages especially in the lungs and gas containing abdominal viscera may appear at pressures in excess of 10 psi. Humans exposed to ten to twelve psi in foxholes at UPSHOT-KNOTHOLE noted no ill effects.

Physical measurements of direct blast pressures following atomic detonation clearly demonstrate that fatal overpressures occur only in the areas where either the nuclear radiation or the thermal radiation will also insure fatality.

CONCLUSIONS: Direct blast is not important as a casualty producing agent except under very unusual circumstances. For military purposes, the effects of direct blast of atomic weapons on personnel can be ignored. Casualties from blast effects result from indirect effects, i.e. missiles or bodily displacement by the blast wave.

RECOMMENDATIONS: No further experimental work on the effects of direct blast as related to an atomic detonation is required. Special shelter experiments are being carried out by other agencies and should be followed as they may lead to basic information of value.

Incl #1

PROJECT AGENCIES AND PROJECT OFFICERS:

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SANDSTONE
Naval Medical Research Institute — R. H. Draeger, Capt, MC, USN

GREENHOUSE
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SNAPPER
Naval Medical Research Institute — R. H. Draeger, Capt, MC, USN

UPSHOT-KNOTHOLE
Naval Medical Research Institute — R. H. Draeger, Capt, MC, USN

OPERATION PARTICIPATION AND SUPPORT:

OPERATION	PROJECT NO.	FUNDS AFSWP	FUNDS OTHER
CROSSROADS	App. 2		
SANDSTONE	7.1-17		
GREENHOUSE	2.9		
SNAPPER	4.2		
UPSHOT-KNOTHOLE	4.2		

REPORTS:

1. App. 2, "Air BlastEffects of an Atomic Bomb Explosion" CROSSROADS, dated 1 August 1946
2. Report No. 33, "Biological and Animal Container Studies" SANDSTONE, dated 1948.
3. WT-8, Annex 2.9, "Blast Injuriesin Foxholes" GREENHOUSE, dated 1951.
4. WT-15, Annex 2.3, "Exposure Containers for the Biomedical Program" GREENHOUSE.
5. WT-527, "Biomedical Exposure Equipment" SNAPPER, dated December 1952.
6. WT-564, "Operation SNAPPER, NPG, Apr-Jun 1952, Final Report"
7. UK-35, "Direct Air Blast Exposure Effects in Animals" UPSHOT-KNOTHOLE, dated June1953.
8. DESERT ROCK IV and V.

SUPPORTING R&D PROJECTS:

1. Navy NM 006 018, Study of Blast.
   Hazardsand tolerance levels in animals and man and the development of protective devices. Panama City, Florida.
2. AEC - a. Studies on direct blast damage, UCLA.
   b. St[redacted]ast damage, Lovelace Clinic,
   [redacted]ON

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Subj: Biomedical Air Blast Injuriss Direct

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3. Zuckerman, "Experimental Work on Physiological Effects of Blast", Ministry of Home Security, RC 108

4. Fisher, R. B., "The Relationship Between Body Size and the Lethal Effects of Blast", Ministry of Home Security, RC 284.

5. Krohn, P.L., et al, "Effect of Blast on the Heart and Head", RC 249, Ministry of Home Security.

6. Clemedson, Carl-Johan, "An Experimental Study on Air Blast Injuries", ACTA Physiolog Scand, Vol. 18:1949.

7. "German Aviation Medicine World War II" published by USAF.

8. Dean, D. M., "Effects of High Explosive Blast on the Lungs", Lancet, 2:1940.

9. Zuckerman, S., "Blast Injuries to the Lungs", Lancet 2:1940.

10. National Research Council, Div of Med Sciences, "Report on Blast Injuries", dated 11 June 1953.

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SECURITY INFORMATION

SUBJECT: Biomedical Thermal Effects

OBJECTIVE: To evaluate the biological thermal radiation hazard from an atomic detonation including possible evasive measures, the protective effects of structures and shelters, and the protective effects of personal equipment including clothing and protective creams.

TEST PROCEDURE: Extensive thermal laboratory and field experiments have been conducted. Close working coordination has been effected with the physical thermal measurements in order to determine characteristics of the thermal pulse. Spectrum, intensity and attenuation factors have been evaluated by physical measuring devices as well as by exposure equipment specifically designed to evaluate physical factors by actually burning biological specimens.

Physical indicators and animals have been utilized to determine the protective effects of various types of shelters including foxholes.

A combination of laboratory and field data have been used to evaluate protective effects of clothing and other personal equipment. An active program has been initiated to develop a skin simulant which will replace the requirement for the use of living biological specimens.

STATUS OF KNOWLEDGE: The time characteristics of the thermal pulse have been determined for yields up to 500 KT. These characteristics make evasive action impossible. The spectral characteristics for airburst have been determined. Surface burst spectral data is not complete.

Threshold values for human skin have been determined for first and second degree burns in human experimentation and extrapolation of animal data obtained in the field and laboratory is adequate for the threshold value of third degree burns. Dark skin is more sensitive than light. This is of particular importance in the range of two to five calories.

Structures and shelters including foxholes offer complete protection from thermal injury so long as there is no line of sight exposure of the target.

Laboratory sources have been developed which adequately simulate the bomb pulse for the production of small area burns. Field experience with the pig indicates no essential difference between small and large area burns on exposed skin. There is no acceptable laboratory large area source available, but it is hoped that a magnesium furnace will be put into operation this year.

Protection afforded by clothing has been partially evaluated in the laboratory a... ...d at UPSHOT-KNOTHOLE. Almost complete protection is afforded by four or ...

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STATUS OF KNOWLEDGE: (Cont'd) systems. The two layer system and the importance of draping has not been resolved. Spectral variations for surface bursts and large yield weapons (above 100 KT) may influence fabric protection. Fire resistant fabrics reduce secondary flame but do not appear appreciably more resistant to transmission of the primary pulse.

4 Layer clothing protects against Everything up to 82 cal/cm. sec.

Standard Navy Department flash cream is effective in protecting otherwise unshielded skin and its possible use in selected operational situations should be considered.

CONCLUSIONS: For operational requirements, basic airburst thermal radiation data relating to effects on unprotected skin is adequate. Spectral variations for surface burst and large yield weapons need further evaluation. The protective effects of clothing (less than four layer system) has been partially evaluated. The influence of fire resistant fabrics, draping, and variations in spectrum is not resolved. The protective effects of shelters is known.

Adequate laboratory sources for small area burns are available but a large area source awaits testing.

RECOMMENDATIONS: The problems associated with the protection offered by clothing can be approached in the laboratory but final verification will require field tests.

Spectral variations can be resolved in the laboratory once accurate physical data is obtained.

The use of the bomb, as a thermal source, for evaluating mass casualty therapeutic methods may be required.

PROJECT AGENCIES AND PROJECT OFFICERS:

<u>RANGER</u>	
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Subj: Biomedical Thermal Effects

OPERATION PARTICIPATION AND SUPPORT:	OPERATION	PROJECT NO.	FUNDS AFSWP	FUNDS OTHER
	RANGER	Report No. 10		
	GREENHOUSE	2.2, 2.7		
	BUSTER-JANGLE	4.2, 4.2a		
	TUMBLER-SNAPPER	4.6		
	UPSHOT-KNOTHOLE	8.5		

REPORTS:

1. WT-201, "Operation RANGER, Report 10, Thermal and Ionizing Radiation Measurements"
2. Memo Report 3-102, U.S. NRDL "Informal Report Operation RANGER", 2 March 1951.
3. WT-6, Scientific Director's Report, Annex 2.2, GREENHOUSE, "Control Studies Performed in the United States and at Eniwetok Parts VII, VIII, and IX" Nuclear Explosions 1951.
4. WT-9, Scientific Director's Report, Annex 2.7, GREENHOUSE, "Thermal-Radiation Injury" Nuclear Explosions 1951.
5. WT-21, Scientific Director's Report, Vol II, Part II, GREENHOUSE "Evaluation of Progress 2", 1951.
6. WT-316, Project 4.2a, BUSTER, "Thermal Effects on Animals (Rats), Oct-Nov 1951.
7. WT-362, Project 4.2, BUSTER, "Thermal Effects on Animals (Dogs)", June 10, 1952.
8. WT-527, Project 4.2, SNAPPER, "Biomedical Exposure Equipment", Apr-June 1952.
9. WT-531, Project 4.6, SNAPPER, "The Time-Course of Thermal Radiation as Measured by Burns in Pigs", Apr-June 1952.
10. WT-564, SNAPPER, "Final Report to the Test Director" 1953.
11. UKP-60, Project 8.5, UPSHOT-KNOTHOLE, "Thermal Radiation Protection Afforded Test Animals by Fabric Assemblies" June 1953.
12. DESERT ROCK I, II, III, IV and V.

SUPPORTING R&D PROJECTS: For a complete summary of supporting program, see Memorandum for Chairman and Members, Joint Panel on the Medical Aspects of Atomic Warfare, dated 15 December 1952, RDB file BAW 113/1.

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BIBLIOGRAPHY: (Cont'd)

2. H. E. Pearse, J. T. Payne and L. Hogg, "The Experimental Study of Flash Burns", Annals of Surgery, CXXX (1949), 774.

3. J. T. Payne et al., "Comparative Effects of Large Area High and Low Temperature Burns", UR 175 (Rochester, N.Y.: University of Rochester Atomic Energy Project, 1951), in press.

4. E. H. Leach, R. A. Peters and R. J. Rossiter, "Experimental Thermal Burns, Especially the Moderate Temperature Burn", Quarterly Journal of Experimental Physiology, XXXII, (1943-44), 67.

5. H. D. Kingsley, L. Hogg, Jr., J. T. Payne and J. H. Morton, "Studies in Prolonged Anesthesia in Swine and Dogs", UR 1952 (Rochester, N.Y.: University of Rochester Atomic Energy Project, 1951), p 65.

6. J. W. Brooks, R. Robinett, and E. I. Evans, "A Standard Burn--Method of Production and Observations on the Blood Picture Following Its Production", Annals of Surgery - to be published.

7. M. Tsuzuki, "Report on the Medical Studies of the Effects of the Atomic Bomb", General Report, Atomic Bomb Casualty Comm. (Wash: National Research Council, 1947), App. 9.

8. E. I. Evans, "The Burn Problem in Atomic Warfare", Journal of the American Medical Association, CXLIII, (1950), 1143.

9. E. H. Pearse and J. T. Payne, "Mechanical and Thermal Injury from the Atomic Bomb" New England Journal of Medicine, CCXLI, (1949), 647.

10. Brooks, J. W., Robinett, P., Largen, T. L., Evans, E. I., "A Standard Contact Burn", S.G.&O, 93:543-554, Nov 51.

SUBJECT: Thermal Effects on the Eye

OBJECTIVE:

A. To determine to what degree the flash of a nuclear detonation impairs the vision and reduces the efficiency of military personnel during daylight and night operations.

B. To evaluate protective devices developed for the purpose of protecting the eye against visual impairment resulting from excessive exposure to light.

TEST PROCEDURE:

Utilizing human volunteers and animals, a number of observations have been made. Human volunteers were exposed during both daylight and nighttime operations and then studies made of their visual acuity. In addition, a theoretical and practical laboratory approach was initiated in 1951 and is being continued at the U.S.A.F. School of Aviation Medicine.

STATUS OF KNOWLEDGE:

Subjective and objective examination of the Japanese survivors of Hiroshima and Nagasaki demonstrated surprisingly little evidence of thermal injury to the eyes. In one group of a thousand persons within two thousand yards of ground zero no lesions of the fundus were found which could be attributed to the thermal effects of the bomb. Even the eye lids (when the patient has sustained severe facial burn) showed only occasional injury. A history of temporary (a few minutes) blindness was elicited from a few patients and an occasional individual stated he was blind for a matter of days. In this latter case it was the opinion of the attending medical personnel that hysteria might be responsible.

For discussion purposes, thermal eye injury is divided into three categories.

1. Temporary (flash) blindness: Evaluation of human volunteers (air crews) at BUSTER established no visual impairment under daylight conditions where other hazards (heat, blast and radiation) were not encountered. Under simulated nighttime conditions at TUMBLER-SNAPPER and UPSHOT-KNOTHOLE, there was definite temporary flash blindness in unprotected individuals.

Individuals must be focused so that the detonation is in the direct forward field of vision. Even under nighttime conditions, there is no impairment of vision unless the fireball is in the forward field of vision.

2. Retinal Injury: Four instances of retinal burns in humans have been encountered. Three of these occured under complete dark adaptations at Operation SNAPPER and one occurred under predawn (30 minutes) lighting conditions at Operation UPSHOT-KNOTHOLE. In two of the above a permanent scotoma was

During [redacted] burns were sustained in rabbits to a distance of 28.5 miles; however, the significance of this finding in its relation to human retinal burns awaits further laboratory investigation. 3 out of 10 at 42 miles.

(3) cases burned at U-K.

3. Protective Devices: A number of protective devices have been used. Experience at UPSHOT-KNOTHOLE demonstrated that if all wave lengths were screened out by adequate glasses except between 600 and 680 millimicrons, there was complete protection. 1 Burn out of 60 thru the filters.

CONCLUSIONS:

Flash blindness during daylight and night operations will not present an operational problem for ground troops. Daylight operations will not be impaired for air crews. Loss of visual acuity under nighttime conditions presents an operational hazard for unprotected air crews. Glasses similar to those used at UPSHOT-KNOTHOLE will give adequate protection for all operational requirements.

If the fireball is in the forward field of vision, retinal burns may be produced.

RECOMMENDATIONS:

Further laboratory work is indicated to evaluate the findings in test animals in Operation UPSHOT-KNOTHOLE. Additional field tests are not required for human volunteers except to evaluate new types of protective filters.

PROJECT AGENCIES AND PROJECT OFFICERS:

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TUMBLER-SNAPPER
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Army Medical Center — R. L. Forest, Maj, USA

UPSHOT-KNOTHOLE
School of Aviation Medicine — V. A. Byrnes, Col, MC, USAF

OPERATION PARTICIPATION AND SUPPORT:

OPERATION	PROJECT NO.	FUNDS: AFSWP	FUNDS: OTHER
BUSTER-JANGLE	4.3		
TUMBLER-SNAPPER	4.5		
UPSHOT-KNOTHOLE	4.5		

REPORTS:

1. WT-341, Project 4.3, BUSTER, "Flash Blindness", Oct-Nov '51
2. WT-530, Project 4.5, SNAPPER, "Flash Blindness", Apr-June 1952
3. WT-564, Operation SNAPPER, "Flash Blindness", Final Report to the Test Director, 1953
4. UKP-36, Project 4.5, UPSHOT-KNOTHOLE, "Flash Blindness" Preliminary Report, June 1953.

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Subj: Thermal Effects on the Eye

SUPPORTING R&D PROJECTS: Studies on Flash Blindness. USAF School of Aviation Medicine.

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1. J. J. Flick, MD. "Ocular Lesions Following the Atomic Bombing of Hiroshima and Nagasaki", MMDC 936, 13 May 1947.
2. Benkwith, C. B., "Retinal Hemorrhage Seen in an Atomic Bomb Casualty", Am. J. Ophth, 29:7991, July 1946
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SECURITY INFORMATION

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This [redacted] consists of 8 pages
No. [redacted] Series A

SUBJECT: Radiological Hazards From An ABD, Alpha, Beta, and Gamma Radiation

OBJECTIVE: To determine the nuclear radiation hazards from an atomic detonation including both internal and external hazards.

PROCEDURES: The primary objective of field tests has been to study phenomenology as it occurs following a bomb detonation so that suitable radiation sources could be developed and evaluated for use in the laboratory. Biomedical procedures have been closely coordinated with applicable physical measurements of the radiation perameters. In addition to actual exposure of biological specimens, where correlations of lethality and various organ system responses with physical measurements were made, phantom studies were done to evaluate the importance of depth dosage. These tests were carried out under conditions of varying weapon designs and yields.

Extensive pathological examination of the exposed animals, including serial sacrifice studies, were performed to obtain a better basic understanding of the radiation syndrome.

Internal hazards were evaluated when suitable conditions were available. The internal hazard problem has been compared to existing animal data derived from laboratory experiments and a limited number of human accidental exposures.

The Japanese data has been thoroughly analyzed and in the past year additional whole body radiation of humans has been accomplished in conjunction with therapeutic radiation problems.

Protective shelters and personal equipment, including gas masks, collective protectors and clothing have been tested in the field.

STATUS OF KNOWLEDGE: A. <u>External Radiation</u>

1. Gamma

a. Acute effects: The mechanism of action of radiation is unknown. The spectrum of the prompt and the residual radiation is still largely unknown, but comparison of effects in the field to those produced by laboratory radiation sources allows us to make reasonable assumptions regarding possible effects.

Operational military tolerances have been established. Recent human whole body studies in the laboratory have verified the tolerances in the range of 0-150 roentgens. In the mid-lethal and lethal range, the dosages for man are not well established. Due to biological variation, the lethal dosage for a given individual

SUBJECT: Radiological Hazards From An ABD, Alpha, Beta, and Gamma Radiation

Monkeys-
LD-50-550-565 r

The re The relative biological effectiveness of gamma radiation, as determined in the mouse, is essentially one (1) compared with a 230 KVP x-ray machine. The RBE for man is not definite.

Variations in dose rate from 1 minute to 40 minutes do not essentially affect the biological response. The data has not been determined for either extremely high dosages delivered in a short period of time or for chronic dosages, except to indicate that field data at very high dose rates in the mid-lethal and lethal range correlates well with laboratory calibrations at lower dosage rates.

The effective energy of a residual field and its corresponding RBE is under study at the present time.

Pathological studies of animals at field tests reveal no essential difference other than for species variation from the pathological examination of Japanese fatalities at Hiroshima and Nagasaki.

The prompt reactions or immediately incapacitating effects of vastly super-lethal dosages is unknown. Recent laboratory work will be discussed at the meeting.

Shielding afforded by military structures, including fox holes, is known or can be roughly calculated for any specific structure.

b. Chronic effects: No information has been obtained under field conditions. A number of R and D projects sponsored by various agencies have allowed us to make general predictions as to possible effects. All of these projects, however, have been done with animals and there is very little data available on man. The NEPA estimates and those appearing in the Handbook on Atomic Weapons for Medical Officers represent best available information. In general, there seems to be a significant recovery following radiation injury so that tolerances to integrated chronic dosages may be significantly increased over those to single acute exposures.

2. Beta.

The measurement of the external beta hazard with currently available instruments is difficult. Various estimates based on laboratory type measurements and theoretical calculations have

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SUBJECT: Radiological Hazards From An ABD, Alpha, Beta and Gamma Radiation

indicated beta-gamma ratios of from 10 - 1 to several hundred to one depending upon the conditions of measurement. Estimates based on the opinions of experienced radiologists indicate that for usual operational conditions there will be no external beta hazard unless there is an associated large gamma hazard. This has been verified, for the case of fall out contamination, by experience at field tests and a recent specific project designed to measure the relative beta hazard. There are certain instances, however, involving isolated problems in which the beta hazard may be important. Include Carl Houghton's problem in aviation.

3. Shielding

Adequate knowledge exists or can be calculated for the shielding effects of military structures and field fortifications.

B. Internal Radiation

The biological and physical half lifes of the important fission fragments are known. The relative importance of alpha and beta emitters when retained in the body in amounts above tolerance levels is not known. Studies on radium and mesothorium have been extrapolated for alpha emitters in excess of tolerance amounts. The problem of the single "hot" particle has not been resolved.

a. Inhalation. The importance of particle size is known, Studies based on JANGLE indicated no internal hazard from a surface or sub-surface burst unless an overwhelming external gamma hazard is present. For air crews operating through an atomic cloud, there is no significant internal hazard unless an overwhelming external hazard is also present.

Protective devices, including gas masks and collective protectors, have been tested and give adequate protection.

b. Ingestion. Food and water tolerances have been established which are reasonable for operational purposes. Standard engineer field purification systems will adequately decontaminate water. Food may be decontaminated by removing the external contaminated surface.

CONCLUSIONS: Current operational requirements can be fulfilled with presently available external effects information. Further laboratory work on humans in the range of 1 - 200 roentgens, including long-term follow up of the effects, is indicated.

Available lethal effects information is adequate except in the field of prompt response to overwhelming dosages. Individual

SUBJECT: Radiological Hazards From An ABD, Alpha, Beta and Gamma Radiation

biological variations and the relatively small ground area involved in the range between 300 - 600 roentgens do not justify further mortality studies in animals.

Further data is required to verify predictions of the effects of repeated exposures in the acute tolerance range.

The internal hazard is not of operational importance. If an internal hazard is present, available protective devices are adequate.

RECOMMENDATIONS: Continue laboratory studies on the mechanism and effects of whole body radiation on man in the range of 50 - 200 roentgens.

Field studies are required to determine the range of immediate incapacitative doses.

Continue studies on gamma spectrum, particularly involving the residual field.

Long-term inhalation studies are required to evaluate the "single hot particle" problem.

When therapeutic procedures are developed which might influence the effect of radiation injury, field studies involving mass casualty principles will be required.

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<u>RANGER</u>

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SUBJECT: Radiological Hazards From An ABD, Alpha. Beta and Gamma Radiation

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N.M.R.I.	W. Chambers, LCDR. USN
UPSHOT-KNOTHOLE	
Cambridge Research Center	E. A. Pinson, LtCol USAF
Army Medical Service Grad. School	J. T. Brennan, Lt Col, MC
Chemical Corps Rad. Lab.	J. M. Roady

OPERATION PARTICIPATION AND SUPPORT

OPERATION	PROJECT NO.	FUNDS AFSWP	FUNDS OTHER
CROSSROADS	App. 3,5,15,16		
RANGER	Report #10		
GREENHOUSE	2.2, 2.4, 2.5, 2.6		
BUSTER-JANGLE	2.3, 2.7, 2.46, 2.5a-1, 2.5a-2, 6.3-2, 4.1		
TUMBLER-SNAPPER	4.4		
UPSHOT-KNOTHOLE	4.1, 4.7		

SUBJECT: Radiological Hazards From An ABD, Alpha, Beta and Gamma Radiation

REPORTS

CROSSROADS

App. 3 "The Gross Autopsy Findings and a Statistical Study of the Mortality in the Animals Exposed at Bikini" 1 March 1947

App. No. 5, "Statistical Analysis of Hematologic (Red Blood Cell Count) Data on Pigs Test Able"

App. 15 "Hemorrhagic Syndrome of Acute Ionizing Radiation Illness Produced in Animals" 7 October 1948

App. 16 "Mutations Produced by Atomic Bomb Irradiation of Neurospra Crassa" 7 March 1949

RANGER

WT-201, Report 10, "Program Reports - Gross Weapons Measurements"
USNRDL Memo Report 3-102 Informal Report Oper. Ranger 2 Mar 1951

GREENHOUSE

WT-6, "Control Studies in U.S. and Eniwetok" 1952

WT-16, "Pathology of Radiation Injury" 1952

WT-18, "Control Studies in U.S. and Eniwetok" 1952

WT-21, "Scientific Director's Report, Evaluation of Program 2" 1952

WT-22, "Mortality Rate As A Function of Distance"

WT-43, "Experimental Data Obtained in the Field"

WT-103, "Operation GREENHOUSE, Scientific Director's Report, Vol. III. 1951"

BUSTER-JANGLE

WT-315, "Radiation Dosimetry"

WT-332, "Gamma Depth Dose Measurement in Unit Density Material"

WT-394, "Airborne Particle Studies"

WT-395, "Fall Out Particle Studies"

WT-396, "Biological Injury From Particle Inhalation"

WT-402, "Evaluation of [illegible]ratory Hazards Associated With Vehicul[illegible]

SUBJECT: Radiological Hazards From An ABD. Alpha, Beta and Gamma Radiation

BUSTER-JANGLE (Cont'd)

WT-370, "Gamma Radiation Measurements"

WT-393, "Foxhole Shielding of Gamma Radiation"

TUMBLER-SNAPPER

WT-529, "Gamma Depth Dose Measurement In Unit Density Material"

UPSHOT-KNOTHOLE

UKP-8, "Radioactive Particle Studies Inside Aircraft"

UKP-34, "The Radiation Hazard to Personnel Within An Atomic Cloud"

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SUBJECT: Radiological Hazards From An ABD, Alpha, Beta and Gamma Radiation

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SUBJECT: Radiological Hazards From an ABD, Neutrons

OBJECTIVE: The measurement of neutron effects on various biological systems.

TEST PROCEDURE: The responses of biological systems have been calibrated against known doses of laboratory x-rays permitting the evaluation of neutron effects in terms of REM units. Mice were exposed to the thermal column of the Los Alamos water boiler where a reasonable estimate of the physical damage received in REP units could be determined for the various biological systems tested.

Mice and some other biological materials were exposed at weapons tests within seven inch thick lead hemispheres designed to protect them from blast and thermal radiation and to eliminate gamma radiation which would otherwise affect the same systems studied for neutron effects.

STATUS OF KNOWLEDGE: Lethality, atrophy of the spleen and thymus, mitotic depression of the testes, and iron uptake by the bone marrow all showed an RBE of 1.5 to 2.0 between x-rays and thermal neutrons for mice exposed in the laboratory. RBE for cataracts was greater by a factor of four or more. Two strains of mice showing different sensitivities for x-rays demonstrated the same RBE for thermal neutrons. Little experimental data for fast neutron exposures is available.

Initial calculations indicated that the animals exposed at weapons tests within the hemispheres demonstrated about 90% of the neutron effect that they would have shown had they been exposed to the neutron radiation of the weapons in free air. Recent work indicates that such shields attenuate neutrons more severely than this, and that the correct figure may be no higher than 50%, depending to some extent upon the external neutron spectrum.

Various biological test systems in mice characteristically showed different REM values at any given station in the weapons tests, and the time of peak death following midlethal exposures was less than that for comparable x-ray doses, indicating that organ system radiosensitivities and species mechanisms of death may differ somewhat among different ionizing radiations. Greatest reliability and consistency of data was found among lethality and spleen and thymus atrophy, with the latter proving most practical for correlation with physical data.

Comparison of REM data with physical measurements showed the biological response to be quite sensitive to neutron spectrum. It is clear that these biological systems operate

STATUS OF KNOWLEDGE (Cont'd):

as excellent indicators of the integrated biological effect of bomb neutrons even in the absence of physical spectral data; and their use in conjunction with limited physical data allows them to be employed as relative neutron dosimeters.

As predicted, the importance of neutron biological effect compared with bomb gamma varied markedly with weapon design and yield, ranging from insignificant where weapon design and yield were unfavorable to neutrons to a factor at least as great as gamma (at the range of mid-lethal dosage) in cases favorable to neutron release from the fission assembly.

Nevada test data showed neutrons penetrate soil less well than gammas; although foxholes provided less protection from scattered neutrons than from scattered gammas. Neutron induced activity in biological material has been shown to present no personnel hazard.

Because of its sensitivity to specific ionization, genetic material has proven useful in differentiating the importance of gamma and neutron effects when both are present.

Meager data concerning neutron spectrum and relating neutron effects to animal size and species differences has made extrapolation of the weapons test information to man extremely unreliable. A qualitative theory has been established permitting the mouse field data to be viewed as the upper limit to the neutron response (in term of REM units) to be expected in man, but there is little experimental confirmation of the assumptions involved.

Physical theory predicts that the range of nuclear radiation effects, including neutrons, will be very greatly increased at high altitudes. The above limitations on the extrapolation of weapons test neutron data to man do not permit an accurate estimate of the increase in neutron biological effects to be anticipated under these circumstances.

There is no current work being done with high doses of neutrons delivered at very high dose rates, comparable with gamma experimentation now in progress where a prompt biological response has been demonstrated under similar circumstances.

CONCLUSIONS:

The biological data suggest that the mechanisms of response to neutrons may be somewhat different from those to x-rays in a given species.

The effect on neutron REM values of protective lead hemispheres used in [illegible] has been improperly evaluated in the past.

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Subj: Radiological Hazards From An ABD, Neutrons

CONCLUSIONS (Cont'd):

Neutron biological effects appear to be very sensitive to the neutron spectrum, and it is clear that biological systems are good indicators of the integrated effect of a neutron spectrum, but good correlation is hampered by lack of physical data.

The mouse data shows that neutron biological effects are important only in those circumstances where weapon yield and configuration favors neutron release and that in these instances the neutron effect may be roughly comparable to the gamma effect with distance, perhaps being even greater at distances less than that where mid-lethal gamma dose is delivered.

Foxhole shielding appears to be less effective in protecting against neutrons than against gammas.

The RBE of neutrons for cataract formation is high.

At high altitudes the range of neutrons relative to other effects becomes increasingly important.

RECOMMENDATIONS:

1. To predict neutron response in man;

   a. More experimental data is required;

      (1) on the response of mammalian species to neutrons of different energies,

      (2) on the response of animals of different size and species.

   b. Calculations of neutron penetration in tissue should be made.

2. One more field test should be performed to obtain good physical data outside and inside the hemispheres to tie in previous biological data with good physical measurements.

   a. Studies of physical spectrum to be correlated with biological data,

   b. Data should be obtained on the effect of the lead hemispheres on the neutron spectrum.

3. Studies of high doses of neutrons with larger animals when delivered at very high dose rates.

4. Participation in high altitude tests if programmed.

Subj: Radiological Hazards From an ABD, Neutrons

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OPERATION PARTICIPATION AND SUPPORT:

OPERATION	PROJECT NO.	FUNDS AFSWP	FUNDS OTHER
CROSSROADS	A pp. 17		
GREENHOUSE	2.2, 2.3, 2.4, 2.5 & 6.1		
TUMBLER-SNAPPER	4.2 & 4.3		
UPSHOT-KNOTHOLE	4.8		

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TUMBLER-SNAPPER

WT-527, "Biomedical Exposure Equipment"
WT-528, "The Biological Effectiveness of Neutron Radiation from Nuclear Weapons"
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Subj: Radiological Hazards From an ABD, Neutrons

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SUBJECT: Combined Injury

OBJECTIVE: To determine the effects of combined blast, thermal and radiation injuries.

TEST PROCEDURE: No specific field tests have been designed with this objective. Experience at GREENHOUSE and UPSHOT-KNOTHOLE has given field data.

STATUS OF KNOWLEDGE: Analysis of the Japanese data indicated that there was a number of combined injuries but the nature of the data made evaluation difficult. Charts will be presented at the conference which show the probabilities of combined radiation and thermal burns occurring in the same individual.

a. Burns and Radiation

(1) At GREENHOUSE it was demonstrated that "if thermal burns progress to a point of partial epithelialization, healing proceeds in spite of mortal radiation injury. However, granulating biopsy wounds or burns become gangrenous or slough when signs of radiation sickness develop". Experience at UPSHOT-KNOTHOLE was similar.

(2) Laboratory experience at Medical College of Virginia in 1950 indicated synergism. Small, non-lethal contact burns gave a high mortality rate when combined with non-lethal amounts of radiation. These results were only partially confirmed in the past year. Radiant energy burns apparently produce a milder systemic effect and therefore a lower incidence of mortality when combined with non-lethal radiation.

(3) Recent work at the Naval Radiological Defense Laboratory with hot water burns was similar to the contact burns at Virginia. Radiant energy burns have not been fully analyzed as yet.

b. Fractures and Burns

Combined fractures and burns have been studied in dogs. The results indicated that plaster casts may be contra-indicated in the treatment of fractures with overlying burns. Intramedullary nailing even through the burn was more satisfactory. The applicability to humans has not been evaluated.

c. Radiation and Surgery

Surgery (resection of bowel) following radiation had no effect on either the recovery from surgery or the course of the radiation syndrome.

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Subj: Combined Injury

CONCLUSIONS: Combined thermal and radiation injuries represent a relatively small fraction of the total casualty load. Combined blast and thermal injuries represent an undetermined portion of the total casualty load.

There is no evidence to indicate that radiant energy burns and radiation will materially affect the clinical management of patients.

RECOMMENDATIONS: Further work is required to evaluate the problem of fractures complicated with burns.

PROJECT AGENCIES AND PROJECT OFFICERS:

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UPSHOT-KNOTHOLE - Quartermaster Research and Development Labs and Army Medical Service Graduate School, Osterling and J. T. Brennan

OPERATION PARTICIPATION AND SUPPORT:

GREENHOUSE - Project 2.7

UPSHOT-KNOTHOLE - Project 8.5

REPORTS:

WT-9, "Thermal Radiation Injury" GREENHOUSE

UKP-60 "Thermal Radiation Protection Afforded Test Animals by Fabric Assemblies" UPSHOT-KNOTHOLE

SUPPORTING R&D PROJECTS:

Army, Thermal Burn Studies, Medical College of Virginia

Army, "The Treatment of Fractures Complicated by Contiguous Burns" University of Pennsylvania

Army, "Experimental Burns and Fractures", H. Allen.

Army, "Study of Combined Thermal Radiation and X-irradiation effects in mice", W. H. Parr

AFSWP, "Thermal and Combined Thermal and Radiation Effects on Biological Systems", Naval Radiological Defense Lab.

AEC, "Effects of Surgery on Dogs Following Whole Body Radiation", Western Reserve University