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OPERATION HARDTACK

Projects 8.7/2.12d

THERMAL RADIATION FROM VERY-LOW-YIELD BURSTS

April-October 1958

Headquarters Field Command
Defense Atomic Support Agency
Sandia B , Albuquerque, New Mexico

June 10, 1960

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The objectives of Project 8.7 were to determine the thermal radiant exposure (cal/cm^2) versus distance from ground zero for a fractional-kiloton nuclear device and the total luminous flux (lumens/ft^2) as a function of both time and distance from ground zero.

The objectives of Project 2.12d at shot Hamilton were to determine the thermal radiant exposure versus distance for a fractional-kiloton detonation, and to compare the experimentally obtained radiant-exposure values with those calculated from existing scaling laws.

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FOREWORD

This report has had classified material removed in order to make the information available on an unclassified, open publication basis, to any interested parties. This effort to declassify this report has been accomplished specifically to support the Department of Defense Nuclear Test Personnel Review (NTPR) Program. The objective is to facilitate studies of the low levels of radiation received by some individuals during the atmospheric nuclear test program by making as much information as possible available to all interested parties.

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It is the belief of the individuals who have participated in preparing this report by deleting the classified material and of the Defense Nuclear Agency that the report accurately portrays the contents of the original and that the deleted material is of little or no significance to studies into the amounts or types of radiation received by any individuals during the atmospheric nuclear test program.

FOREWORD

This report presents the final results of one of the projects participating in the military-effect programs of Operation Hardtack. Overall information about this and the other military-effect projects can be obtained from ITR-1660, the "Summary Report of the Commander, Task Unit 3." This technical summary includes: (1) tables listing each detonation with its yield, type, environment, meteorological conditions, etc.; (2) maps showing shot locations; (3) discussions of results by programs; (4) summaries of objectives, procedures, results, etc., for all projects; and (5) a listing of project reports for the military-effect programs.

ABSTRACT

The objectives of Project 8.7 were to determine the thermal radiant exposure (cal/cm^2) versus distance from ground zero for a fractional-kiloton nuclear device and the total luminous flux (lumens/ft^2) as a function of both time and distance from ground zero.

The luminous flux was sufficiently high to saturate the illumination sensor system, therefore no peak luminous flux information was recorded. The measured values for thermal radiation agree with the established scaling laws for a surface detonation.

The objectives of Project 2.12d at Shot Hamilton were to determine the thermal radiant exposure versus distance for a fractional-kiloton detonation, and to compare the experimentally obtained radiant-exposure values with those calculated from existing scaling laws. Shot Hamilton was detonated on a 50-foot-high wooden tower. Radiant exposures for Shot Hamilton were measured at horizontal distances of 175 to 700 feet from ground zero using thermistor calorimeters. The equipment operated satisfactorily in that only two instruments failed out of a total of sixteen independent instruments and recorders. However, the results were, in general, inconclusive because of the very-low yield of the device and also perhaps because shielding material in the bomb tower partially obscured the thermal line of sight. All except one station registered less than 1 cal/cm^2 which was about the lowest limit of detection of the calorimeters.

PREFACE

This is a joint report by the U. S. Army Chemical Warfare Laboratories (CWL) and the U. S. Naval Radiological Defense Laboratory (NRDL).

To facilitate the presentation of the procedure and results it has been divided into two parts: (1) NRDL evaluation of radiant exposure and irradiance at and (2) CWL evaluation of radiant exposure at and Hamilton.

During Operation Hardtack, the U. S. Naval Radiological Defense Laboratory was requested by the U. S. Army Chemical Warfare Laboratories, Army Chemical Center, to assist in the prosecution of Project 8.7, "Thermal Radiation from a Very-Low-Yield Burst." The assistance to Project 8.7 was carried out by NRDL as an extension of NRDL's Project 8.4, "Thermal Radiation Measurements with High Time Resolution."

The authors wish to acknowledge the cooperation of the personnel of the Weapons Effects Test Group of Field Command, AFSWP, Sandia Base, Albuquerque, New Mexico, in the installation of thermal measurement stations and administration of the project, namely Lt Col W. S. Isengard, Capt J. Thomas, and MSgt Allen.

Thanks are due the personnel of the Radiation Characteristics and Effects Branch of NRDL for assistance in the field in setting up and calibrating the thermal measurement stations, particularly Mr. F. Laughridge. Acknowledgment also is given to Messrs R. Day and R. W. Hillendahl for their criticism and assistance in the preparation of this report.

Appreciation is expressed to the members of Project 8.1, Naval Material Laboratory (NML) New York. for the loan and reading of four of their thermal exposure meters (rem) which were used at

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Part I NRDL EVALUATION of THERMAL RADIANT EXPOSURE and IRRADIANCE at

OBJECTIVES

The objectives of Project 8.7 were to determine the thermal radiant exposure versus distance from ground zero for a very-low-yield (fractional-kiloton) nuclear device and to compare these values with theoretical results obtained from existing thermal scaling laws. Specifically, the objectives were to: (1) accumulate basic thermal data for fractional-kiloton weapons for which data were not previously available; (2) measure radiant exposure and irradiance for ground stations in order to examine the existing scaling laws; and (3) compare the values of radiant exposure at ground stations as determined by three different types of instruments.

The objective of NRDL's participation in Project 8.7 was to measure the total thermal radiant energy from a fractional surface detonation More specifically, the objectives were: (1) to measure the total thermal energy as a function of distance; and (2) to measure the total luminous flux as a function of time and distance.

STATION LAYOUT

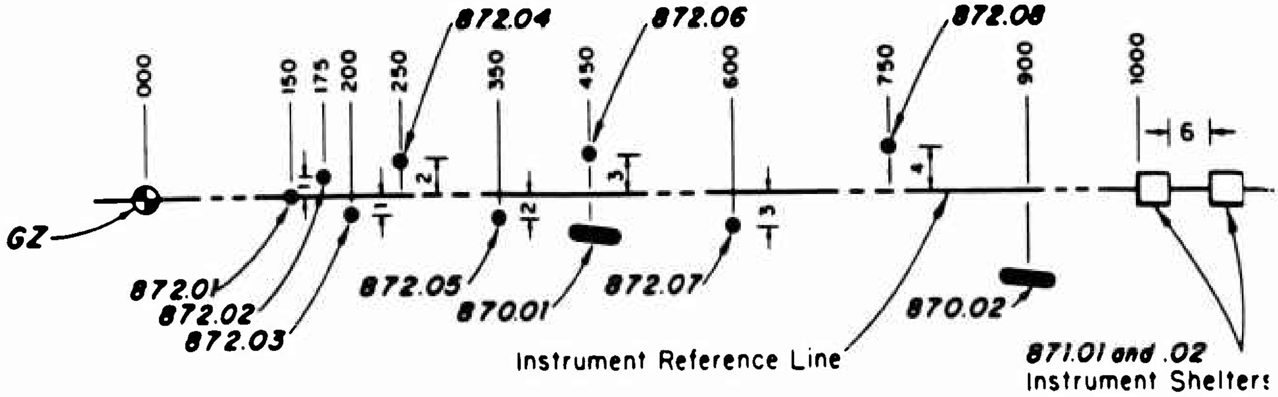
Radiant exposure measurements were made on two shots, There were ten ground-instrument stations ranging in distance from 150 to 900 feet from ground zero as shown in Figure 1.

Three types of instruments were used to measure the thermal radiation exposure. These instrument types were the Chemical Warfare Laboratories (CWL) thermistor calorimeter, the U. S. Naval Radiological Defense Laboratory (NRDL) disk calorimeter, and the Naval Material Laboratory (NML) thermal-radiant-exposure meter. Table 1 lists the assigned station number and the distance from ground zero in the first two columns respectively, and the three different participating laboratories in Columns 3, 4, and 5.

Figure 2 is a photograph of Yvonne Island which depicts the tower for NRDL Station 870.02 and the station location of NRDL Station 870.01 and ground zero for both

INSTRUMENTATION

NRDL Instrumentation. Since the yield of was unpredictable, the thermal sensors were selected to measure thermal energies from yield ranges of 0.010 to 0.100 kt. The thermal instruments involved were: NRDL MK 6F calorimeters, with a sensitivity of 1.0 and 1.5 (cal/cm^2)/mv, NRDL MK 8F twenty-junction calorimeters with a sensitivity of 0.02 (cal/cm^2)/mv, and NRDL MK 8F seven-junction calorimeters with a sensitivity of 0.1 (cal/cm^2)/mv (Reference 1). The measurement of luminous flux was made with Weston photronic cells, Type RRV (sensitive to visible spectra) used in conjunction with neutron density filters (Reference 2). To complete the stations, 16-mm gun-sight-aiming-point (GSAP) cameras were included for the purpose of instrument orientation to ground zero. The signals from the thermal and photronic sensors were registered by Heiland oscillographic recorders on Kodak microfile film running at a speed of 24 in/sec.



Not To Scale
All Distances in Feet

Figure 1 Ground station locations,

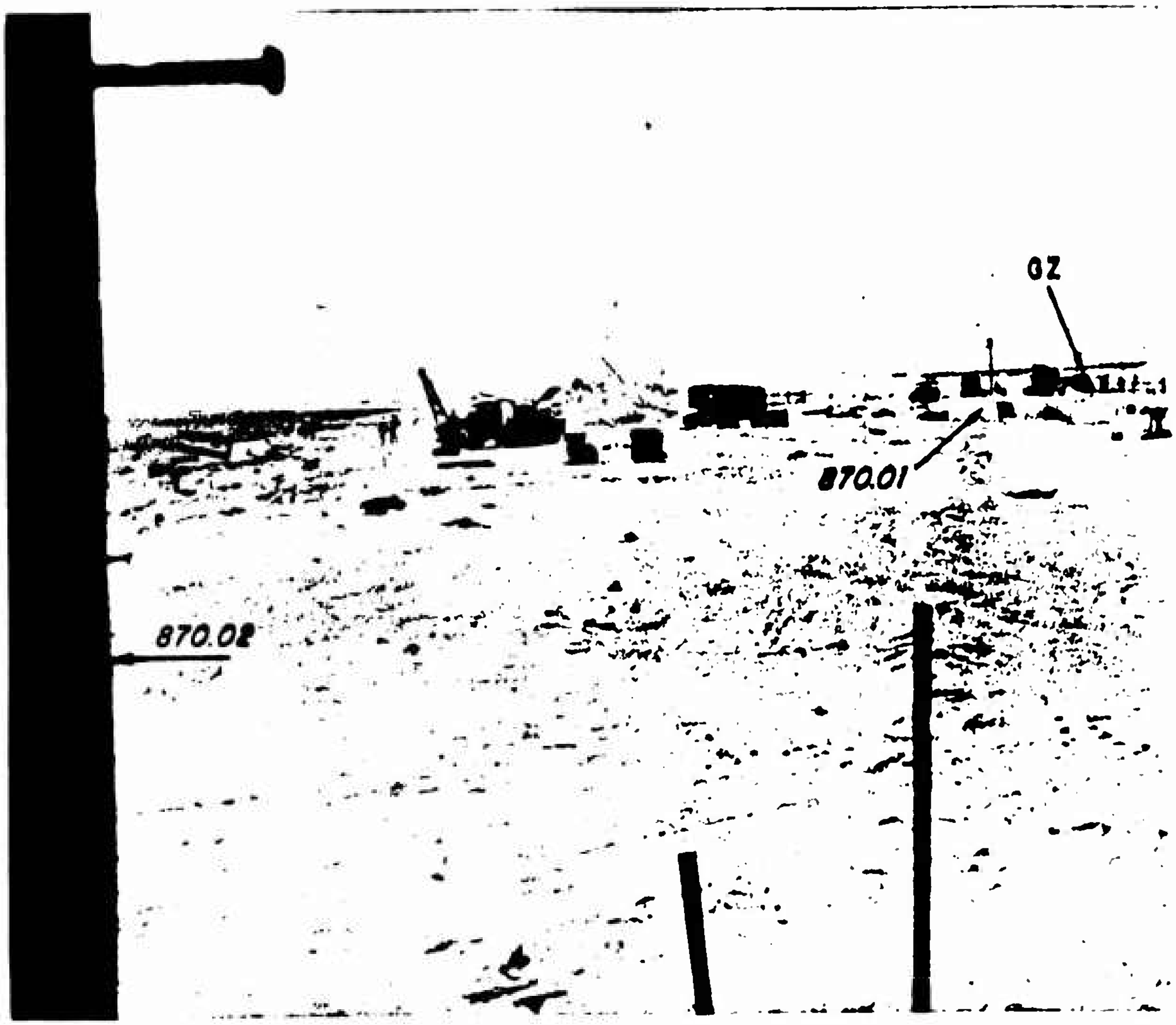


Figure 2 Station orientation from NRDL Station 870.02 at 900 feet, looking toward Station 870.01 at 450 feet and ground zero.

The NRDL instrumentation was located at two stations; Station 870.01 at 450 feet from ground zero and Station 870.02 at 900 feet from ground zero. At each station there were eight NRDL calorimeters, four Weston photronic cells, and two 16-mm GSAP cameras. The sensing instruments were housed in a pod, facing ground zero, which can be seen in the photograph of Station 870.02 (Figure 3); it is diagrammed in Figure 4 which gives the instrument position layout and the associated GSAP cameras. The pod was supported by a 10-foot tower, which in turn was attached to an NRDL sub-surface type shelter. The recording oscillograph, junction box, and 24-volt batteries were located in the "hull" of the underground shelters (Figures 5 and 6). Table 2 lists the position, oscillograph channel, instrument, and GSAP camera relationship for each station.

Instrument Calibrations. All thermal instruments were calibrated at NRDL prior to the operation by exposure to the Mitchell high-intensity thermal radiation source. Several series of calibration runs were made prior to shipment of the instruments to the EPG. The calibration procedure was repeated upon return to NRDL (Reference 3). The electrical calibrations for the calorimeters were accomplished by introducing standard millivolt signals in series with the final field circuits on the night of D-1.

TABLE 1 GROUND STATION LOCATION FOR EACH PARTICIPATING LABORATORY

Station Number	Ground Zero Distance, feet	Participating Laboratories		
872.01	150	CWL		
872.02	175	CWL		
872.03	200	CWL		
872.04	250	CWL		
872.05	350	CWL		NML
872.06	450	CWL		NML
870.01	450		NRDL	
872.07	600	CWL		NML
872.08	750	CWL		NML
870.02	900		NRDL	

The Weston photronic cells were calibrated by use of a laboratory-calibrated Weston photometer, using a 500-watt projection bulb as a source (Figure 7). The light source was placed at ten different distances from the instruments and photometer sensors. The light levels which corresponded to the different distances were recorded on the Heiland oscillograph and the corresponding reading of the photometer was noted. The above procedure was repeated on D+2 for the postshot calibration.

TEST PROCEDURES

The NRDL Thermal Radiation Branch has made measurements in most of the nuclear weapons test operations during the past 7 years. The calibration of the thermal radiation calorimeters has been standardized, and the field measurement of thermal radiation from nuclear weapons with these calorimeters has remained essentially the same during this period.

The thermal radiation calorimeter is basically a simple instrument. A copper-constantan thermocouple is attached to a blackened copper or silver disk, of known physical parameters. Impinging thermal radiation causes the disk to rise in temperature, which in turn produces an electromotive force in the thermocouple. This voltage is introduced into a film-type recording oscillograph, and a permanent record of the magnitude of thermal radiation is obtained. Corrections must be applied for heat losses due to convection, conduction, and re-radiation. These corrections are necessary both for calibration and field use. More specific details about the

Figure 3 Mount and instrument positions for NRDL Station 870.02.

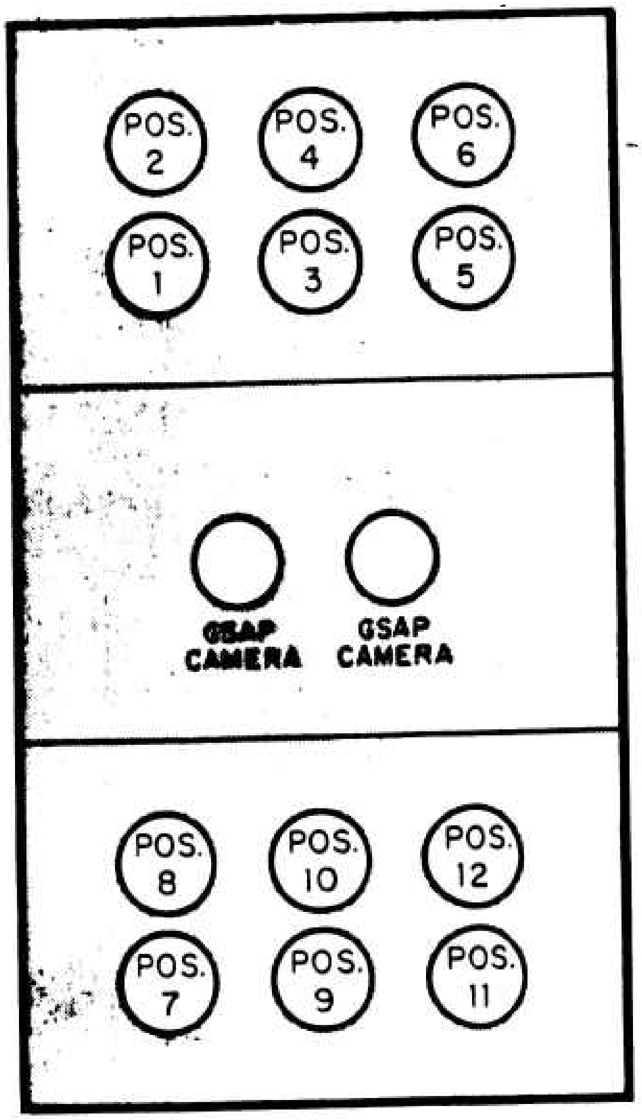


Figure 4 Thermal instrument position layout for NRDL Stations 870.02 and 870.01.

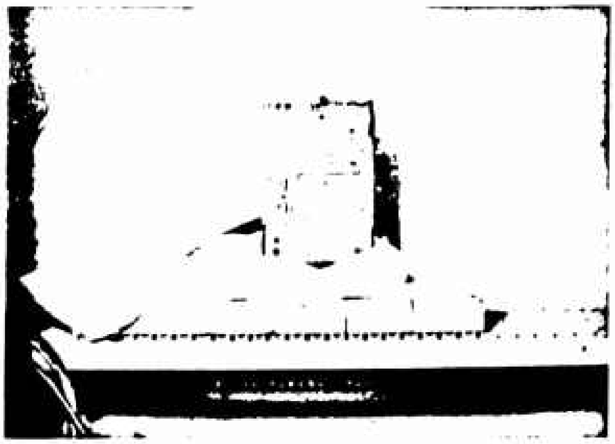


Figure 5 Front view of NRDL instrument shelter showing Heiland oscillograph recorder and battery power supply. (Note: Faraday cage and lead shielding bricks have been removed.)

Figure 6 Rear view of NRDL instrument shelter showing junction box installation.

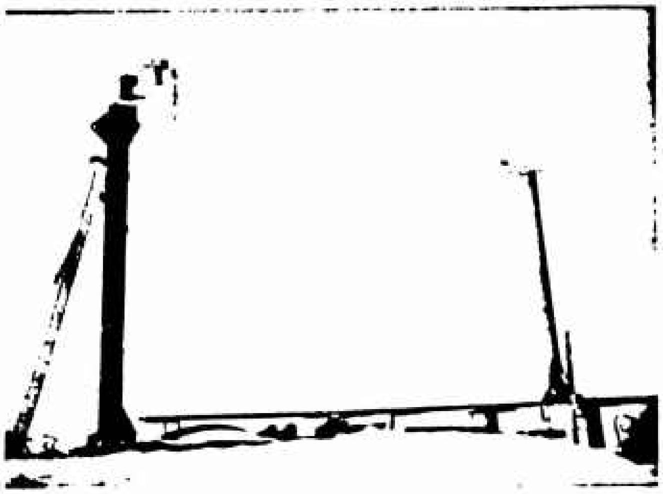


Figure 7 Typical photocell calibration system.

instrumentation of field stations and the calibration of the thermal radiation calorimeters have been given in preceding paragraphs of this report. Further information may be obtained by consulting References 1, 3, 4, 5, and 6.

RESULTS AND DISCUSSION

The average TE ($\bar{Q}$) incident at each station, from the device, is located at the bottom of the tables.

The majority of the instruments at Station 870.01 (Table 3) functioned smoothly. However, Instrument Number YY19, Channel 3 was too sensitive and its trace deflected off scale. This does not impair the accuracy of the measurement to any great degree as the time during which the trace was off scale is so short that the integrated magnitude of the off-scale portion of the time trace is very small when compared to the major portion of the record.

Instrument Number YY20, Channel 10 had a thermal calibration which was undependable. Thus, its Q value was not included in the computation for the average total thermal energy at the station.

At Station 870.02 (Table 4) every thermal sensor functioned, with the exception of Instrument Number XX48, Channel 3, which had an erratic trace on the recording film; this was caused by an open thermocouple in the instrument.

Figures 8 and 9 are curves plotted from typical data located in Tables 3 and 4 respectively. The left ordinate is the deflection in Benson-Lehner units. The right ordinate is the TE in cal·cm^{-2}, the units of the abscissa are time, in seconds. The solid line curve is the measured deflection transcribed from the oscillograph record. The broken line curve represents the measured deflection of the oscillograph, corrected for heat losses.

Figure 10 shows the curves obtained by differentiating the corrected calorimeter curves of Figures 8 and 9. Due to the relatively long time response of the NRDL calorimeter, and the extremely short time history of these curves can be used only in determining an approximate time to second maximum of the thermal pulse for this device.

Figure 11 is a plot of the average total thermal energy listed at the bottom of Tables 3 and 4, versus distance from ground zero. This curve has a slope equal to 2, which indicates that the thermal radiation decreases as the inverse square of the distance from ground zero. This curve also shows that at short distances, there is very little effect on the transmission of thermal radiation by the intervening atmosphere.

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Photometry. The luminous flux was of such a magnitude that the galvanometers which measured the output of the photronic cells were driven off scale. The peak luminosity that this instrumentation system could measure was about 10^7 lumens; therefore, it is possible that the peak luminosity was orders of magnitude greater than the limit of the instrumentation.

Photography. Figure 12 is a plot of the fireball diameter versus time. The information was obtained from high speed films taken by Edgerton, Germeshausen & Grier, Inc. (EG&G) for the

Weapons Effects Test Group at Field Command, AFSWP. It is included here to give late-time fireball diameters and approximate time to minimum and to second maximum (Reference 8).

Meteorology. Table 5 lists weather conditions at H hour, This information was obtained from Field Command, AFSWP, Albuquerque, New Mexico.

TABLE 5 METEOROLOGICAL DATA AT TIME ZERO,

Temperature, 86 degrees	Sky Conditions:
Dew Point, 78 degrees	1,500 feet, scattered clouds
Relative Humidity, 77 percent	3,500 feet, broken clouds
Barometric Pressure, 29.73	high overcast
	visibility, 10 miles
	wind, 080 degrees, 16 knots

CONCLUSIONS

The average total radiant energy measured at both the 450-foot and 900-foot stations for compare well with results obtained from established scaling relationships using known and measured parameters.

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The empirical equation used for the calculation of Q, the total radiant energy, as a function of distance is:

$$Q = \frac{PWT}{4\pi (SR)^2}$$

Where: Q = total radiant energy, $\mathrm{cal \cdot cm^{-2}}$
W = yield, TNT equivalent in tons × 10^9 cal/ton
T = transmission, fractional
P = device partition, fractional
SR = distance from ground zero, cm

The known and measured values are: $W =$ $Q_{450} =$, $Q_{900} =$
$SR = 450$ and 900 feet, T at short distances = 1.0.

From the above, the calculated partition, P, is This partition agrees closely with partitions of devices of any yield, detonated under similar conditions (Reference 8).

Since the transmission of the atmosphere at short distances is essentially equal to 1.0, it would be expected that the thermal radiation would follow an inverse square relationship as the distance from ground zero increases. The curve through the experimental points (Figure 11) has a slope equal to 2, showing that the above condition is satisfied.

RECOMMENDATIONS

There is no information available to predict luminous flux for short slant ranges from fractional-kiloton nuclear weapons, and since this measurement is important for flash blindness consideration, it would be highly desirable to further study this phenomenon with more adequate instrumentation.

Part 2 CWL EVALUATION of THERMAL RADIANT EXPOSURE at and HAMILTON

OBJECTIVES

The objectives of Project 2.12d at Shot Hamilton were the same as those for Project 8.7 (Part 1), except that radiant exposure values only were measured, and only one type of instrument, the thermistor calorimeter, was used.

BACKGROUND AND THEORY

Thermal radiation has been measured by various agencies during most of the previous nuclear tests (Reference 9). However, thermal radiation has not been measured previously for nuclear devices of the expected from and Hamilton. Measurement of the thermal radiation for such weapons was necessary because of the uncertainty in making extensive extrapolations from scaling laws that had been derived from larger-yield data.

The radiant exposures at various slant ranges from air and surface burst weapons can be calculated from the following expressions:

$$Q = \frac{3.16 \times 10^6 \, W(\bar{T})}{D^2} \quad \text{cal/cm}^2 \text{ (air burst)}$$

$$Q = \frac{1.35 \times 10^6 \, W(\bar{T})}{D^2} \quad \text{cal/cm}^2 \text{ (surface burst)}$$

Where: Q = radiant exposure, cal/cm^2
$\bar{T}$ = atmospheric transmissivity
W = weapon yield, kt
D = slant range, yds

The formulas were derived (Reference 10) on the assumption that the thermal partition of thermal energy is $^1/_3$ for an air burst and $^1/_7$ for a surface burst.

The value $\bar{T} = 1$, was used in calculating the theoretical values of radiant exposure as the transmissivity is very nearly unity for the small distances involved, 150 to 900 feet, (Reference 17).

STATION LAYOUT

Radiant exposure was measured for two surface shots. There were ten ground stations ranging in distance from 150 to 900 feet from ground zero as shown in Figure 1. Three types of instruments were used to measure the thermal radiation exposure. The instrumentation used at each station is given in Table 1. The instrument types used were the Chemical Warfare Laboratories (CWL) thermistor calorimeter, the U. S. Naval Radiological Defense Laboratory (NRDL) disk calorimeter, and the Naval Material Laboratory (NML) thermal-radiant-exposure meter.

Radiant exposure was measured for Shot Hamilton at the Nevada Test Site (NTS). This shot was fired on a 50-foot wooden tower. There were eight ground instrument stations ranging from 175 to 700 feet from ground zero (Figure 13). Two independent calorimeters were used at each of the eight distances. The distances for each station are given in Table 6. Figures 14, 15, and 16 show the thermistor calorimeter instrumentation at Shot Hamilton. The setup

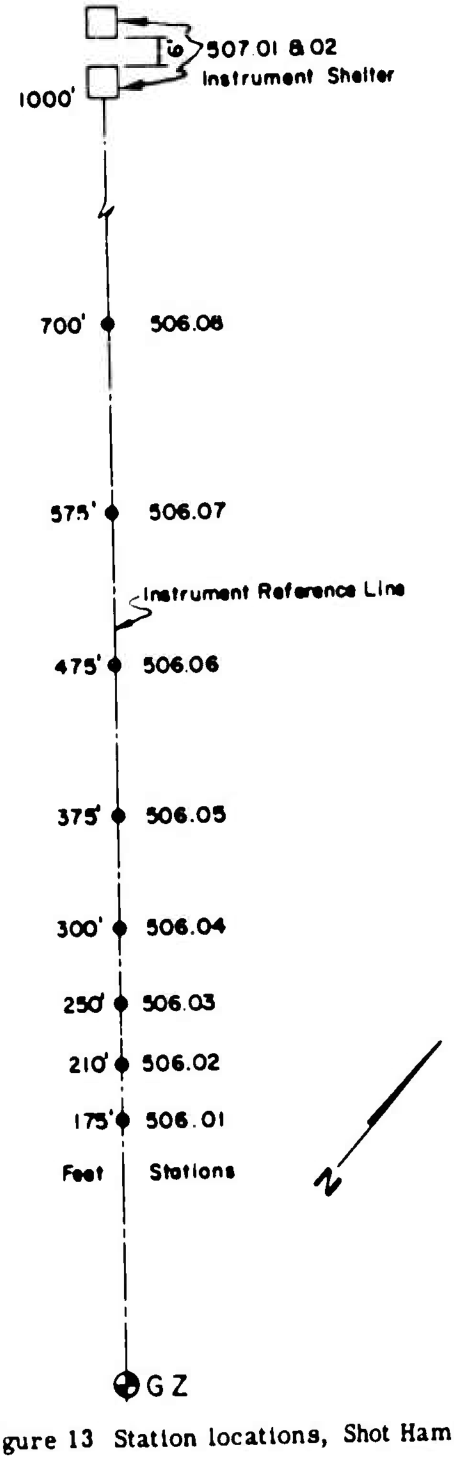

Figure 13 Station locations, Shot Hamilton.

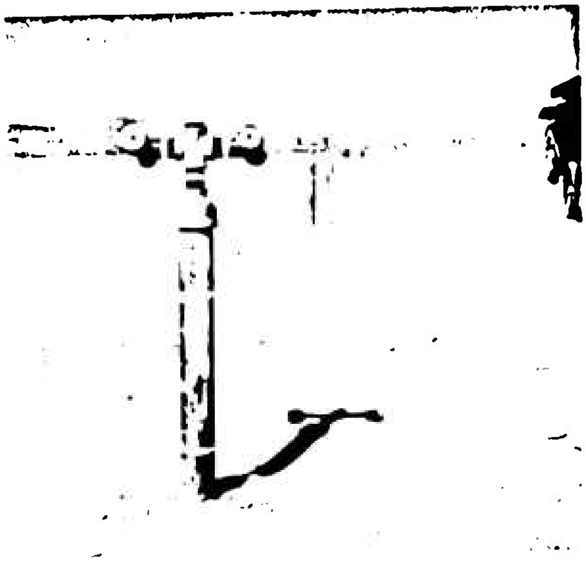

Figure 14 Typical ground instrument station for thermistor calorimeter.

Figure 15 Instrument shelter for Esterline-Angus recorders used with thermistor calorimeters.

used at Shot Hamilton was the same as that at except for station distances from ground zero.

INSTRUMENTATION

CWL Instrumentation. The theory and calibration of the thermistor calorimeter are fully covered in Reference 11. The instrument is essentially a bead-type thermistor, embedded in one end of a solid silver cylinder. Radiation incident on the other end of the cylinder results in a temperature rise of the silver cylinder and embedded thermistor. The thermistor, a semiconductor, composed of oxides of manganese, nickel, and cobalt, has a coefficient of electrical resistance of -3.9 pct/C at 25 C. The particular thermistor used in this test was the VECO-32A11 (Reference 12). The change in electrical resistance causes a variation in the current at the recording milliammeter. The silver cylinder is insulated by Teflon, the whole assembly being mounted in a hermetically sealed brass housing fitted with a hemispherical pyrex window, as shown in Figure 17. The complete unit is 2.5 inches in diameter and 6.5 inches long.

Figure 16 View of instrument shelters and thermal line to shot tower.

TABLE 6 GROUND STATION INSTRUMENTATION, SHOT HAMILTON, IN FEET

Station Number	Ground Zero Distance	Slant Distance
506.01	175	182
506.02	210	216
506.03	250	255
506.04	300	304
506.05	375	378
506.06	475	478
506.07	575	577
506.08	700	702

This instrument was designed to be an absolute instrument, such that no calibration is required. Results obtained at Operation Redwing (Reference 13) indicate that calibration of the thermistor calorimeter against other instruments, assumed to be standards, is of little or no use. Accordingly, the radiant exposures were calculated for Operation Hardtack without any reference to secondary calibration standards.

The basic equation involved for the thermistor calorimeter is:

$$H = mst$$

Where H is the radiant exposure in calories per square centimeter, m is the mass, in grams, of the silver cylinder, s is the specific heat of silver, and t is the temperature rise of the silver cylinder due to the incident thermal radiation.

The mass, m, was obtained by weighing the silver cylinder, to within 0.1 gram, which is to three significant figures. The hole in the silver cylinder, in which the thermistor was silver pasted, was 0.1 inch in diameter and 0.25 inch deep. Elementary arithmetic and direct experimental weighing show that at the worst, only 2 percent error can be introduced by considering the hole empty or full of silver or glass. For simplicity and with negligible loss of accuracy, the weight of the silver cylinder with an empty hole was used.

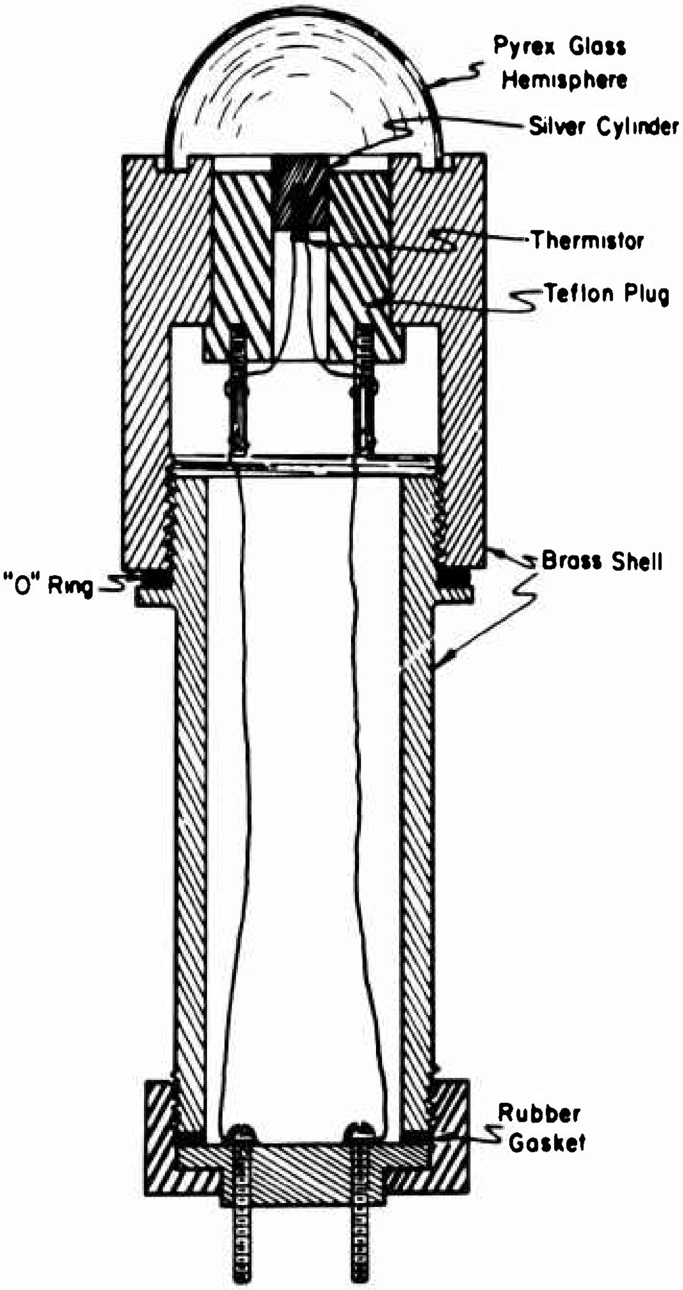

Figure 17 Cross-sectional diagram of thermistor calorimeter.

The value s is the specific heat of silver, 0.056 cgs units (Reference 14).

The temperature rise, t, in the silver cylinder, was obtained by subtracting the initial temperature from the final temperature of the thermistor (and silver cylinder) as read from the recording milliammeter. Each thermistor used was previously calibrated for electrical resistance in ohms versus temperature by immersing the thermistors in a water bath and measuring the resistance directly using a Wheatstone Bridge.

The only correction required in the calculation was a 4 to 6 percent correction which was added to the temperature difference to account for a cooling loss. This was done in each case from the actual experimentally recorded trace for the nuclear shot. Since the cooling loss was small, only 4 to 6 percent in approximately 6 seconds, errors in determining this small cooling rate would be of little consequence for fractional-kiloton devices.

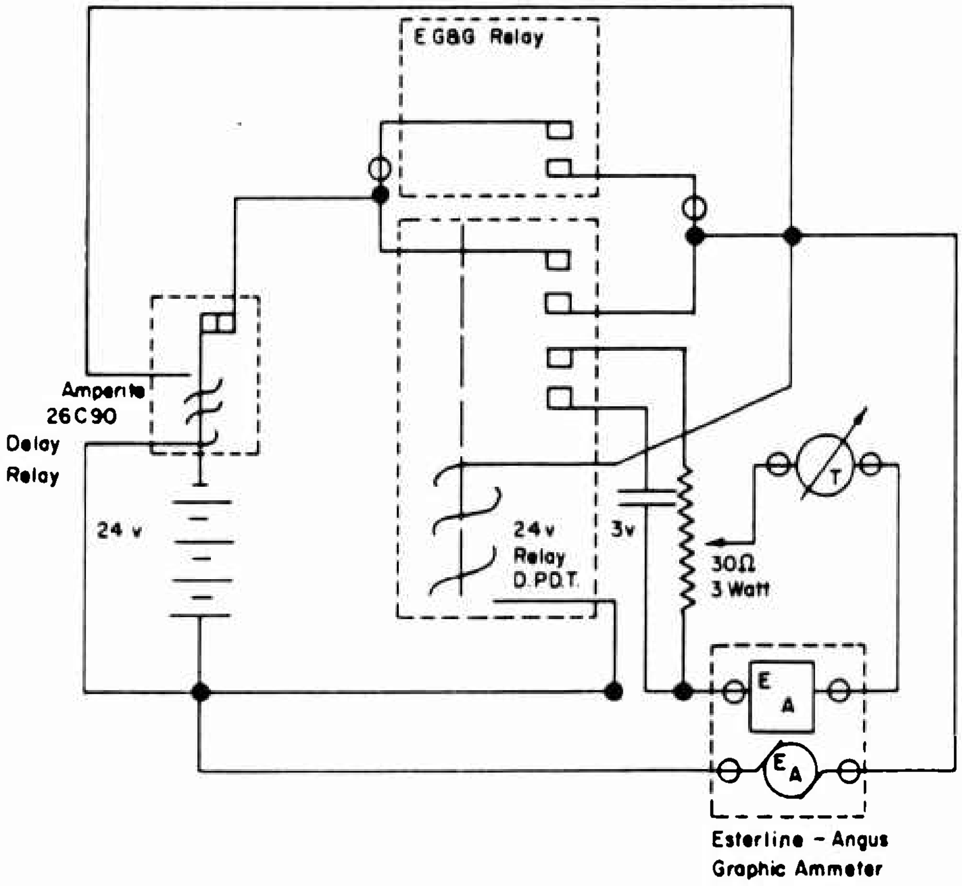

Figure 18 Control-recording circuit for thermistor calorimeter.

A factor of 8 percent was added to the calculated radiation exposure value to account for the transmission loss of the thermal radiation incident through the pyrex glass hemisphere of the calorimeter (Reference 15).

NML Instrumentation. This instrument consisted of several tempilstik pellets in contact with a blackened copper plate. The commercially available tempilstik pellets melt at different temperatures. If the initial (ambient) temperature is known, the thermal radiation exposure may be determined. This instrument is fully described in Reference 16.

OPERATIONS

The thermistor calorimeters were pointed directly toward the fireball as shown in Figure 14. The thermal radiation incident on the camphor-smoke-blackened receiving end of the silver cylinder was 99 percent absorbed (Reference 14, Page 379). The final temperature of the silver cylinder was found using Ohms law and the temperature-versus-resistance curve for each thermistor. The recording equipment (Figure 18) was activated by an H-15-second timing signal.

The equipment itself was operated by standard 6-volt dry cells in series to provide a 24-volt power supply. The timing signal connected the DPDT 24-volt relay, which in turn started the Esterline-Angus recorder motor for high-speed recording (about 1 in/sec of trace) and also furnished 1.7 volts (tapped off from the 30-ohm, 3-watt potentiometer) to the thermistor and recording milliammeter in series. The motor circuit was in series with the Amperite 26C90 thermostatic delay relay. This relay, normally closed, was opened by its thermostat after 90 seconds of operation. This stops the entire operation by shutting off the 24-volt power supply.

The initial temperature of the silver cylinder and thermistor was obtained from the ammeter reading between H−15 seconds and shot time. This initial temperature need not be the same as ambient temperature; in other words, the results would be just as good whether the sun was shining on the instrument or not, since the temperature difference produced by the detonation

radiation is independent of initial temperature of the silver cylinder. The effect of sunlight during operation is negligible, since bright sunlight is normally only about 0.025 (cal/cm^2)/sec. This sunlight radiation is thus negligible in comparison with thermal radiation from even a very-low-yield nuclear device at the distances of interest.

RESULTS

No results were obtained at due to misfiring of the nuclear component.

The results for are given in Table 7. For comparison purposes, the theoretical values of radiant exposure versus slant distance for surface shots of 0.01, 0.02, and 0.03 kt, and the experimental values for are given in Figure 19.

The results for Shot Hamilton are given in Table 8. For comparison purposes, the theoretical values of radiant exposure versus slant distance for aerial shots of 0.005, 0.01, 0.02 and 0.03 kt, and the experimental results for Shot Hamilton are given in Figure 20.

All the theoretical values were calculated using existing scaling laws (Reference 10).

DISCUSSION

Data for the CWL thermistor instruments were obtained during at all except the most distant station, 872.08, at 750 feet. Apparently this failure was due to the

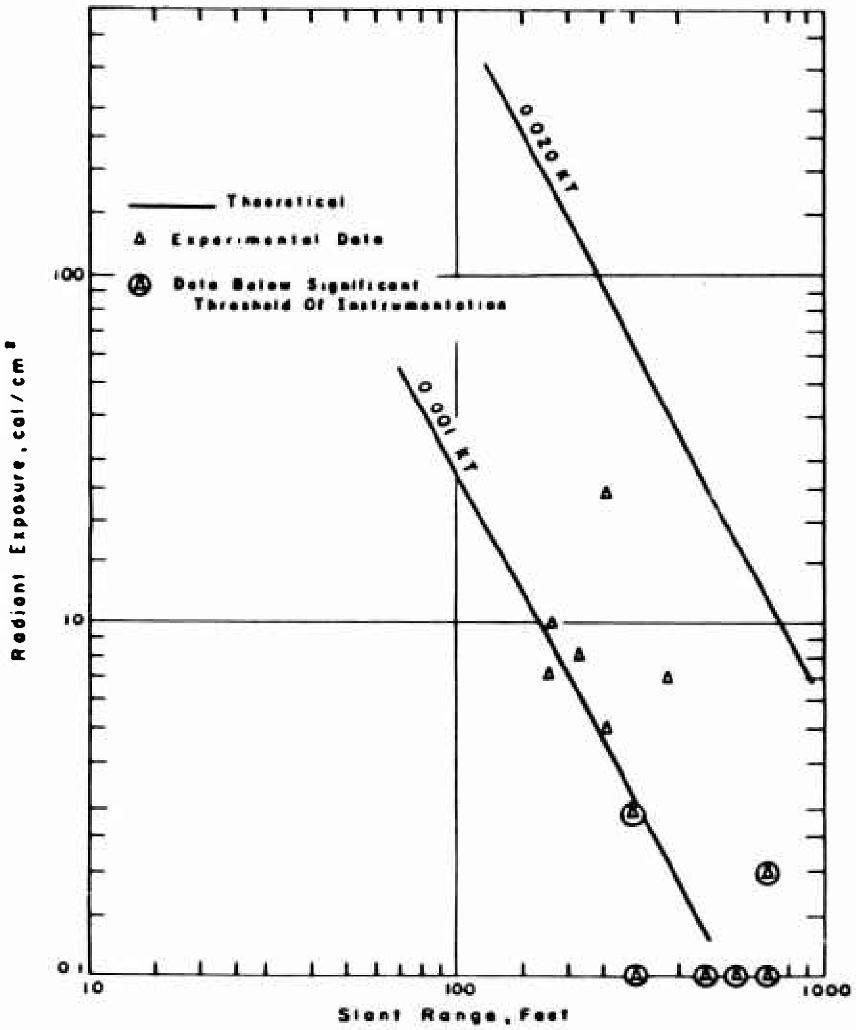

Figure 20 Radiant exposure versus distance, Shot Hamilton

electrical recorder instrument malfunction for which no explanation has been found. Better accuracy could have been obtained at the distant stations by using instruments with higher sensitivity. This was impossible due to the uncertainty of the predicted yield, and because there was sufficient time in preparing for this test to assemble only eight thermistor instruments for the ground stations.

The results obtained with NML instruments indicate only upper limits as the radiant exposure at the indicated stations were less than the threshold values of the NML instruments used. This was due to the fact that only four NML instruments of limited ranges were available at this late stage of the EPG program.

Shot Hamilton at NTS. Only one type of thermal instrument, the thermistor calorimeter, was used at Shot Hamilton. The very-low-yield of the shot resulted in all readings being at or below the threshold accuracy of the instrumentation. The partial obscuration of the thermal line of sight by the addition of last-minute shielding in the device cab contributed to this failure. The equipment was not designed to measure radiant exposure any closer than ± 0.3 cal/cm^2 at any level of radiation. Since nearly all stations registered only tenths of calories, the experimental data shown in Figure 20 is considered as having no real meaning. However, all except two of the sixteen station setups worked perfectly. Apparently the failure for these two was due to the blast jarring of two recording needles, which is almost impossible to avoid completely under nuclear-test conditions.

TABLE 8 RADIANT EXPOSURE VERSUS DISTANCE, SHOT HAMILTON

At 3 feet above ground; no correction for atmospheric attenuation.

Station Number	Slant Distance		Radiant Exposure	Remarks
	ft	yds	cal/cm^2*	
506.01	182	60.7	1.0 to 0.7	—
506.02	216	72.0	— 0.8	did not ink
506.03	255	85.0	2.4 to 0.5	—
506.04	304	101.3	0.1† to 0.3†	—
506.05	378	126.0	0.7	did not ink
506.06	478	159.3	0.1† to 0.1†	—
506.07	577	192.3	0.1† to 0.1†	—
506.08	702	230.7	0.1† to 0.2†	—

* Each column indicated independent set of measured values at stated distances.

† Values below significant threshold of detector instrumentation.

CONCLUSIONS

The radiant-exposure values obtained by the CWL thermistor calorimeter distances of 150 to 450 feet and by the NRDL disk calorimeter data at 450 and 900 feet fit the same experimental curve for This experimental data curve has the same shape as the theoretical curves obtained from existing scaling laws for yields of 0.02 and 0.03 kt.

No significant conclusion can be drawn from the Hamilton data because of the low amounts and the erratic nature of the radiant-exposure values obtained.

RECOMMENDATIONS

None.

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