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POWDER TO PRODUCE LARGE AREA FLASH BURNS

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ABSTRACT

A method of firing magnesium flash powder has been developed to provide a radiant heat source capable of inflicting large area flash burns on laboratory animals. The apparatus and firing techniques have been described in detail, and safety precautions for handling the powder have been stressed. The shape of the heat pulse has been recorded with a radiometer, and the incident radiant thermal energy for various charges at different distances has been measured with a calorimeter. These measurements are quite consistent for each charge-distance combination. The different combinations used provide an exposure range from 2.6 cal/cm^2 to 21.4 cal/cm^2 .

This method provides a practical and dependable radiant heat source for the production of large area flash burns in the laboratory.

INTRODUCTION

Any population exposed to a nuclear weapon detonation would suffer from radiant thermal energy burns (1). Since 1948, this laboratory has been engaged in a study of the nature and effects of these "flash burns" and possible methods of protection from them. The first step for such experimental work was to develop suitable sources of radiant thermal energy capable of inflicting the desired lesions on laboratory animals. After investigating a number of possible sources, the carbon arc and magnesium flash powder were selected as being most practical (2); the former was used to study small lesions, and the latter to produce large area burns.

In the early experiments with magnesium flash powder the charge was placed on a flat plate. Some contact burns were produced because flame and molten particles traveled laterally. It was soon found that this could be avoided by curving the edge of the container to shape the flame upward. Since the large amount of oxide smoke which permeated the corridor and other laboratories when the firing was done inside caused annoyance and concern to others, the work was moved to the roof. Here wooden walls were built for protection from the wind, and the experiments were conducted in the open. Under these conditions as much as three pounds of magnesium flash powder were ignited without disaster. Eventually a standard charge of 124 gms at 30 cms was used to carry out our first experimental studies (2) on flash burns, and the time of burning was determined by high speed motion pictures. However, it was impossible to measure, by calorimetry, the radiant exposure when working outdoors. Inclement weather imposed an additional handicap so a special firing room was built on the lee side of the laboratories.

LABORATORY FOR FIRING MAGNESIUM

The safe burning of magnesium flash powder requires provision against injury of personnel from blast or heat, and disposal of the large amount of white smoke resulting from the ignition. Since our prevailing winds are westerly, a site was chosen at the east end of the laboratories which have only a road and parkway beyond them. A windowless structure of concrete block faced with brick was considered strong enough to withstand the low pressures of blast from laboratory size charges. That part used for a firing room was made 28' x 15' x 11' with a concrete floor having a drain. In a steel trussed roof was placed a 6' x 6' hatch having a pair of hinged, motor-driven covers (Fig. 1), which act as baffles to the east and west when fully opened. Forced draft from an intake fan at the opposite end of the room helps to clear the smoke out through the open hatch.

The burning equipment is placed on a table under the hatch at one end of the room and is separated by a red safety line from storage cabinet, desk, shower and fire extinguishers at the opposite end.

Extra heating of the room is provided when the hatch is open so that in all but extremely cold weather experiments can be carried on without subjecting the animals to a wide variation in ambient temperature. However, it has been our practice not to conduct experiments when there is heavy rain or snow because of possible wetting of the powder.

MAGNESIUM POWDER

Magnesium flash powder has been used since 1944 as a heat source in the study of burns. Fauley and Ivy (3) ignited it in a brass cannon to study various protective creams but this method more likely produces a flame

Figure 1

Schematic Diagram of Laboratory

burn than a true radiant burn. At Wesleyan University a "Hell Roarer" (4) was developed; this emits a jet of burning powder in the manner of a flame thrower.

To obtain a true radiant energy burn, the work in this laboratory has dealt largely with the control of the shape of the fire ball and the reduction of spatter. Early experience with powder blending showed that the best flash might be obtained from a mixture of finely powdered aluminum, magnesium, and an oxidizing agent. The time of burning could be controlled by the amount of oxidizing agent in the blend. An undesirable blast occurred when a burning time of less than 0.5 sec. was used. In the early experiments on the roof a serious blast occurred from adding barium peroxide to the mixture, but with the present blends, where ignition times from 0.5 to 0.9 sec. occur and charges of no more than 200 gms are used, blast is not a problem.

Originally we mixed our own material under a hood equipped with an exhaust fan. The compounds were sifted through 150 mesh screen before they were blended, weighed and packaged. Since this was tedious and hazardous, arrangements were made to purchase a ready mixed powder, packaged in 50 gram capsules, from Kilgore, Inc., of Westerville, Ohio. The approximate composition, by weight, of this material is:

Barium Nitrate	40.5%
Potassium Nitrate	13.5%
Magnesium Grade B	19 %
Aluminum Grade A	27 %

Calibration of Charge

Radiometers have been used to determine the time-radiant energy curve of the burning powder. Fig. 2 is a set of curves from radiometric studies where

Figure 2

Composite Curves of Radiometric Data

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time is expressed in milliseconds on the ordinate and heat intensity in arbitrary units on the abscissa. Both the maxima and minima curves in Fig. 2 are composites of extreme values from all firings. It should be emphasized that neither the maxima nor minima curves could represent the behavior of any single charge. For example, a charge reaching its maximum peak in 0.1 sec. could not maintain this peak for 0.2 sec. as does the curve of maximum values, but rather would fall sharply. The values for mean incident energy given in Table I indicate the area beneath the curve and the small variances, particularly at 30 cm and 45 cm, indicate the close similarity of individual charges.

The measurements with a radiometer are accurate for time and pulse shape but do not accurately reflect the amount of heat delivered. For more precise measurement of incident radiant energy a nickel cone calorimeter developed by Davis (5, 6) has been used. The energy measured at 15, 30 and 45 cm distance from charges of 50, 100 and 150 gms is given in Table I as the mean of ten replications. One hundred fifty grams at 50 cm could not be measured with this equipment.

Method of Firing

The magnesium is placed in a steel tray parallel to the test object and is ignited by an electrical spark from a high voltage transformer. A probe placed in the powder serves as one terminal, and a wire clipped to the base of the firing tray as the other (Fig. 3). Two switches in series are incorporated in the circuit. Closing the first activates a buzzer and warning lights inside and outside the room. The second switch completes the ignition circuit.

Ignition produces a fire ball of burning magnesium oxide above the tray. It is possible to control the shape of the fireball, and thus avoid

Table I

MEAN INCIDENT RADIANT THERMAL ENERGY USING VARIOUS
MAGNESIUM CHARGES AT DIFFERENT DISTANCES.

Tray-skin Distance in cm.	Magnesium Charge in grams	Mean Incident Energy (cal/cm ²)	Variance ² 6
15	50	11.4	2.09
	100	21.4	3.74
	150	-	-
30	50	4.8	0.07
	100	10.2	0.35
	150	13.5	1.28
45	50	2.6	0.06
	100	5.3	0.06
	150	7.6	1.26

FIGURE 3

EQUIPMENT FOR BURNING MAGNESIUM

1. Magnesium tray
2. Probe electrode from HV transformer
3. Return lead to HV transformer
4. Transite shield with 2 inch port
5. Pig
6. Pig holder
7. Cone calorimeter
8. Water lines for cooling of calorimeter

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Figure 3
Equipment for Burning Magnesium

flame contact with the animal, by modifying the tray design. Various dishes used in early work proved unsatisfactory and led to the design of the Y shaped tray illustrated in Fig. 3 and diagrammed in Fig. 4. It is a welded steel trough, 15 inches long with a rectangular cross-section of $3/4$ inch by 1 inch in the lower part, flaring to an opening 3 inches wide at the top. The slot-like base should be large enough to hold all the powder, thus allowing the flared edges to shape the fire ball into a sheet of flame. For charges larger than 150 gms a deeper trough might improve the shaping effect.

Animal Holders

The sheet of flame is broad enough to provide exposure to the entire side of a test animal such as a pig. It has been found that with the animal suspended by the skin of its back at a predetermined distance from the tray and with head, hooves and genitalia protected by asbestos paper, a standing position is simulated and the skin is kept free of wrinkles (7). The entire side of the animal may be exposed in this manner. For smaller area burning the use of a transite shield, like that shown in Fig. 3, allows accurate placement and size of the burn. The anesthetized animal is placed on its back behind a large screen with the selected area against the port and held in this position by a broad, rubber covered bar against its opposite side.

SAFETY PRECAUTIONS

A serious accident occurred in this laboratory in 1953 when an operator was burned about the face and hands by a premature ignition of the powder. As a result, rigid safety precautions have been incorporated into our technique of burning. No smoking or open flames are allowed in the laboratory. The powder is stored in a steel cabinet away from the firing table. Only the operator is allowed forward of the red safety line during preparation of charges.

Figure 4
Diagram of Explosion Tray

This man wears a white, flame-proofed coat buttoned to the neck, a pair of plastic goggles over which he places a welder's mask, heat resistant gloves over light white cotton gloves and shoes with conductive soles. A second person must always be present in the laboratory during the procedure.

A grounded metal plate (Fig. 1) is placed on the floor so the operator must walk across it immediately before placing the charge. A cold, clean tray is used for each explosion. After placing the charge and adjusting the electrodes, the operator returns to the other end of the room where the switches are located. He throws the first switch which turns on the warning lights and activates the buzzer. Only when the second switch is closed will the spark be generated to ignite the powder. In case of a misfire the operator, in protective clothing, goes to the table to make adjustments. No one else is allowed to cross the red line while the magnesium powder is in a firing tray.

After the ignition takes place the operator checks to make sure there is no unburned powder in the tray. This tray is then removed for cleaning and a fresh one is used for the next ignition. About a dozen trays are kept on hand so that one which has not been cooled and cleaned is never used.

SUMMARY AND CONCLUSIONS

1. A method of burning magnesium powder to produce large area flash burns has been described.
2. Physical equipment has been diagrammed and the heat pulse represented graphically.
3. Safety precautions for handling of the powder have been stressed.
4. Magnesium flash powder provides a practical and dependable radiant heat source for the laboratory production of large area flash burns.

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