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TITLE

THE PHYSIOLOGICAL ACTIVITY OF THE CLOUD PRODUCED BY THE COMINGS'H THERMAL GENERATOR

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THE PHYSIOLOGICAL ACTIVITY OF THE CLOUD PRODUCED BY THE

COMINGS' H THERMAL GENERATOR

(F.E. 154 P. of R. S.61)

S U M M A R Y

1. The Comings' H Thermal Generator, which is described in T.D.M.R. 635, generates mustard vapour by passing the hot gases from a heater pellet through a venturi tube into which liquid mustard is drawn by way of holes in its throat. The generator vaporizes 5 pounds of mustard gas in approximately four minutes.
2. Men were exposed at an air temperature of 23°C (73°F), to the cloud from a line source of 96 of these generators, the intervals between generators being 1½ yards.
3. At 75 yards from the source the physiological activity of the cloud, when considered in conjunction with the results of chemical sampling, indicated that the generator was 70 percent efficient. At this distance up to one per cent of the cloud may have been in the form of droplets. It is not known to what extent these droplets may have contributed to the physiological activity.
4. In its present form the generator cannot be transported after charging since liquid mustard is likely to spill into the venturi and contaminate the heater pellet.

E.L. Davies

(E.L. Davies)
Chief Superintendent,
Experimental Station.

HJF/SB

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THE PHYSIOLOGICAL ACTIVITY OF THE CLOUD PRODUCED BY THE COMINGS' H THERMAL GENERATOR,

(F.E. 154- P of R.S. 61)

INTRODUCTION

1. At the request of N.D.R.C. Div. 10 a trial was carried out in which observers were exposed to the cloud from a line source of Comings' H Thermal Generators.
2. The Comings' generator, is described in TDMR No. 635. It consists of a metal container divided into two compartments (see Plate I). The lower compartment houses a block of heater composition (charcoal 13%, ammonium nitrate 79%, ammonium chloride 8%) weighing 2 $\frac{3}{4}$ lbs. The upper compartment is designed to contain 5 pounds of mustard gas and is sealed by a press fit lid.
3. A venturi tube leads from the lower compartment into the air space above the designed level of the liquid in the top compartment. At the base of the venturi are two 0.2 inch holes which are sealed by thin metal discs. (In the generators used at Suffield the holes were 3/16" indiameter and were plugged with Woods metal.)
4. When the heater pellet is ignited (by a pull igniter), the hot gases produced pass up the venturi, melting the metal discs, and allowing mustard gas to be drawn into the gas stream. The mustard laden gases pass out of the generators by way of holes drilled along the rim of the top compartment. In the generators at Suffield there were three such holes each 0.5inches in diameter and spaced 2 inches apart.
5. The generator in its present experimental form cannot be transported when charged, since mustard will readily spill into the top of the venturi and contaminate the heater pellet.

PROCEDURE

6. A line of ninety-six generators, each charged with 5 pounds of stripped HS (90% pure H), and spaced 1 $\frac{1}{2}$ yards apart, was laid out perpendicular to the wind direction. Three sampling and observer lines were then established parallel to this line and at distances of 50, 75 and 150 yards from it.
7. At the 50 yard line three observers sat facing cross wind, on chairs spaced two yards apart across the centre line of the layout. Each observer was dressed in full impregnated clothing, including hood, with his respirator at the gas position. On each upper arm a window had been cut in the clothing and the edges taped down so as to expose an area of bare skin two inches square. Chemical sampling apparatus, sampling continuously at a height of 3 feet was erected immediately upwind of each observer.
8. At the 75 yard line, continuous samples at a height of 3 feet, were taken in triplicate at fifteen yard intervals. At the centre of the line four additional sampling points were erected decreasing the spacing to five yards over a front of thirty yards.
9. Five rows of Jump cards, each of 4 cards, 25 yards apart, were laid at 1, 5, 10, 50 and 75 yards, respectively, down wind of the line of generators.
10. While the layout was being established six observers dressed as follows:-

Battle Dress	non-impregnated.	(All were used (clothes and had (been worn by the (observers for five (days prior to the (trial.
Issue Shirts		
Undershirts	short-armed non-impregnated	
Drawers (pantees)	impregnated	
Socks	non-impregnated	
Boots		

Respirators at the alert position.

Drill order-

were taken for a run and made to carry out physical exercises. They then adjusted respirators to the gas position and stationed themselves immediately downwind of the seven central sampling points on the 75 yard line.

11. At the same time, four observers similarly dressed and carrying portable injectors and bubblers stationed themselves on a line 150 yards from the source.
12. Fifteen minutes after the completion of the warming up exercises all injectors were turned on and the generators lit.
13. During the period of emission the observers on the 75 yard line dug trenches immediately downwind of their sampling points and the observers on the 150 yard line positioned themselves so that they remained in the cloud at all times.
14. After the emission, all injectors were turned off. The observers continued to wear their clothes for 4 hours.

RESULTS

15. Meteorological Conditions.

Wind- 25 ft/sec.
 Value of R ; 1.12
 Gustiness; Horizontal 0.65
 Vertical 0.35
 Air Temperature 23°C (73°F)
 Relative Humidity - 24 per cent
 Grass Temperature 28°C (82°F).
 Temperature Difference (39-4 ft.) -1.3°C (lapse)

16. Of the 96 generators, seventy-one functioned correctly with an average burning time of four minutes. The lids of another twenty were blown off but these generators continued to function, ejecting some of their charging as a spray. Four generators failed to function and one caught fire.
17. The cloud was pure white in colour and hung well to the ground (see Plate II). The wind was steady and the cloud passed over the sampling lines during the whole of the emission.
18. The vapour concentrations obtained on the three sampling lines are tabulated below.

Line	Sampling positions.	CT (mg.min/cu.m.)		
		Iodoplatinate	Chloramine T.	Pyridine
50 yard	3 observer	450		
	positions.	450		
		450		not used.

Line.	Sampling positions.	CT(mg.min./cu.m.)		
		Iodoplatinate.	ChloramineT.	Pyridine
75 yard.	12 central positions (front of 105 yards)	380.	410	-
		300.	310.	380.
		230.	210.	-
		(380.	380.	560
		(300	290.	420
		Observer (380.	300.	330
		front. (450.	320	500.
		(450.	380.	390.
		(450.	390.	470
		(450.	500.	470.
		380	310.	230
		380	390	-
		average	377	350
150 yard.	4 portable samplers.	300		
		50		
		450		not used.
		300		

19. Examination of the observers up to seven days after the exposure showed the following results:-

Line.	Physiological results.
50 yard .	After 24 hours, all three observers, showed erythema over the areas which had been exposed through the windows..In the case of one observer, , one window shifted during his exposure and erythema had developed over a diffuse area on the back of his right shoulder , Forty-eight hours after exposure the area showed pinpoint vesication.
75 yard.	All 6 observers showed vapour effects at 24 hours. In each case, the neck was involved by erythema, and was more prominent in three cases. The armpits showed sharp erythema and in the case of five men the trunk and bends of the elbows were involved. In three cases the bends of the knees showed mild crythema. At seven days the erythema in the armpits of three men was associated with excoriation and free movement was restricted to less than 90° of elevation. These three men were considered casualties. In no case would the dregree of location of the lesions have prevented the man from adjusting his respirator to the gas position.
150 yard.	One observer developed a lesion in the right armpit which by the seventh day was considered to be of casualty severity. Erythema was present in the left armpit and around the neck but not on the trunk or legs. Two observers showed mild effects round the neck and in the armpits. One observer developed only trivial effects in the armpits.

NOTE: During the exposure the men were warm but not hot and sweaty and during the seven day period over which the above observations were made, the observers were engaged in Station fatigues, such as, digging and shovelling, etc. On being classified as casualties they were excused duty.

20. Drop stains were found on all the jump cards from the one yard to the 75 yard line. It is estimated that, for these generators which functioned correctly, about 2 percent of the original charging fell to the ground, between the source and the 75 yard line. The maximum size of droplet falling to ground level close to the source was about 0.4 mm; at 75 yards it was 0.05mm.

DISCUSSION OF RESULTS.

21. Assuming that the Comings' generator is 100% efficient (i.e. 5x0.9 lbs of pure H , is evolved per generator) the dosage on the 75 yard line in this trial

should have been 530 mg.min/cu.m. In para. 18 it will be seen that the average dosages measured by the iodoplatinate, chloramine T and pyridine methods were 380, 350 and 420, respectively. These figures suggest that the generator is 70% efficient. The physiological results obtained on this line confirm this efficiency since they are compatible with a dosage of 300 to 400 mg.min/cu.m. at the temperature prevailing.

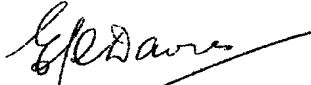
22. Assuming 70% efficiency, ^{the} predicted dosages on the 50 and 150 yard lines are 520 and 220 mg. min/cu.m. respectively. These compare with the measured dosages of 450 and 350. The poor agreement on the 150 yard line can be explained by the fact that the observers on this line are known, from examination of photographs taken during the experiment, to have wandered (due probably to the opacity of the generator cloud) away from the 150 yard line and to have approached the 75 yard line.
23. An analysis of the drop size distribution in the airborne cloud from the Comings' generator is given in the Appendix.

CONCLUSIONS

24. The physiological activity of the cloud produced by the Comings' mustard thermal generator at distances up to 100 yards from the source when considered in conjunction with the results of chemical sampling suggests an effective emission of 70% of the mustard gas content of the generator.
25. The experiment did not indicate the extent to which the droplet content of the cloud contributed to its physiological activity.

This report was written by ^XH.J.Fish (P.R.S.).

HJF:NC


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Chief Superintendent
Experimental Station.

APPENDIX

DROP SIZE DISTRIBUTION IN THE AIRBORNE CLOUD FROM THE COMINGS'

GENERATOR

In a subsidiary trial the particulate nature of the air-borne droplets was investigated by means of thermal precipitators and cascade impactors. The sampling equipment was set up at distances of 10 yards and 50 yards from single generators.

Under the conditions of the trial ($u = 8$ mi/hr., $R = 1.12$, air temperature = 27°C) droplets up to $35\ \mu$ diameter were detected at 10 yards from the generator and up to $25\ \mu$ diameter at 50 yards. Sampling height was 5 ft., except for the cascade impactors at 10 yards, which were at 3 ft.

The mean mass concentrations of droplets were as follows:

10 yards: 2.5 mgm/cu.m.

50 yards: 0.11 mgm/cu.m.

These represent the following percentages of the total theoretical concentration at the two distances.

10 yards: 0.4 percent.

50 yards: 0.1 percent.

At lower temperatures the percentage of the cloud present as droplets would be expected to be larger, but it is probable that for temperatures above 4°C , not more than 1 percent of the cloud would be present as air-borne droplets at distances of 50 yards or more.

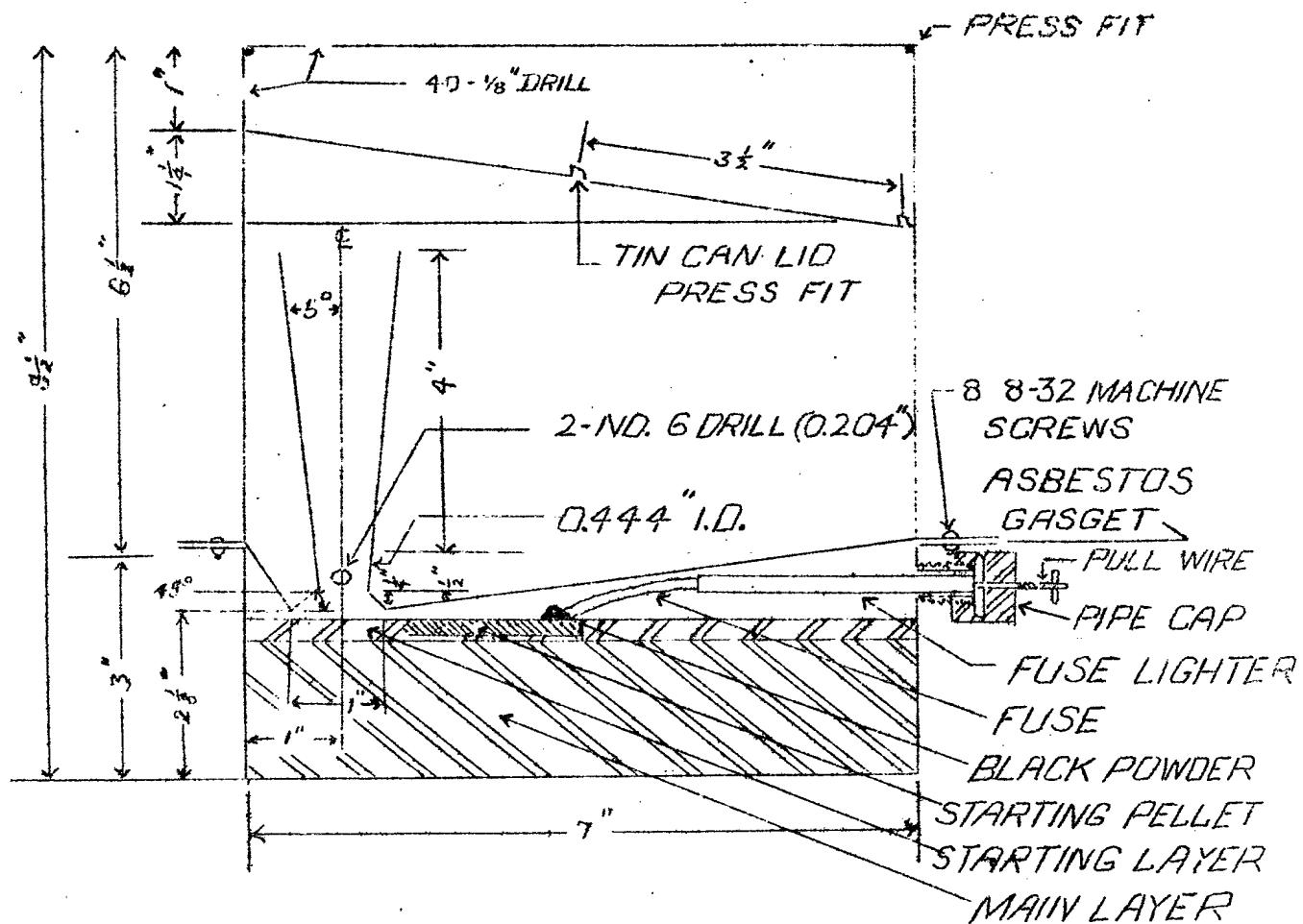


PLATE I
 COMINGS H THERMAL GENERATOR
 SCALE $\frac{1}{2}" = 1"$

REPRODUCED FROM
 T.D.M.R. 635

S.R. No.98

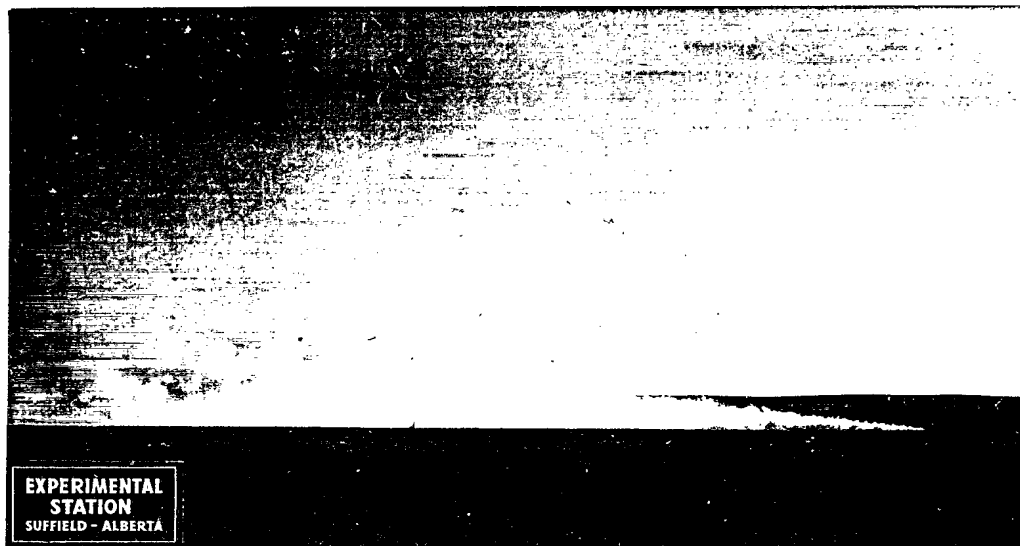


Plate II

5-P-94-564-4

Cloud from generators at zero plus 2 minutes.
(Dark line at centre of cloud is 75 yard line)

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AK

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