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ARMORED FORCE MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

INDEXED

PROJECT NO. 3 - TOXIC GASES IN ARMORED VEHICLES

Final Report On

Sub-Project No. 3-2 - Determination of the Characteristics
and Effects Upon the Crew of Gun Fumes
from Firing of the Weapons in Tanks of
the M5 Series.

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Project No. 3-2

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ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 3-2
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1. PROJECT: No. 3 - Toxic Gases in Armored Vehicles. Final Report on: Sub-Project No. 3-2, Determination of the Characteristics and Effects Upon the Crew of Gun Fumes from Firing of the Weapons in Tanks of the M5 Series.

a. Authority - Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose - To determine the extent of the hazard from fumes released by firing of the weapons in the M5A1 tank.

2. DISCUSSION:

a. Methods and Conditions.

(1) Fire Pattern:

(a) 37mm gun: The piece was fired at the rate of one round every 5 seconds in bursts of 10. One burst was fired every 5 minutes.

(b) Machine Guns: Three belts of 250 rounds each were fired from the turret machine gun in 19 minutes 20 seconds: four belts of 250 rounds each were fired from the bow machine gun in 24 minutes 5 seconds. The intervals between belts varied from 1 minute 20 seconds to 3 minutes 10 seconds.

(2) Ammunition: 37mm. A.P. M74 with tracer. Machine Gun: Caliber .30 ball.

(3) Tank operation: Tank buttoned-up, full crew in tank, and engine idling at 500 to 600 rpm. Tail wind 3 mph. In test 1, with the 37mm gun and in both machine gun trials, the bulkhead ports were closed and the bow ventilating fan was at full exhaust. Test 2, 37mm, bulkhead ports closed, fan off, Test 3, 37mm, bulkhead ports open, fan on full exhaust.

(4) Analysis: Details of the analytical procedures used were reported previously (Project 3-1, 3-5, February 15, 1943). Air samples were analyzed for carbon monoxide and ammonia. Air samples were not analyzed for nitrous fumes, earlier tests having indicated the absence of significant amounts.

3. CONCLUSIONS:

a. 37mm gun:

(1) Under all conditions tested the average air concentrations of carbon monoxide were well within the acceptable limits of 0.05%.

(2) The maximum accumulation of carbon monoxide in the blood of crew members during firing of the 37 Mm gun was 3.4% which is of no practical significance.

(3) Carbon Monoxide concentrations were slightly higher when the bow ventilating fan was on exhaust than when it was not running.

(4) Ammonia concentrations did not reach troublesome levels. (less than 60 ppm).

b. Machine guns:

(1) The average concentrations of carbon monoxide were well within the acceptable limit of 0.05% in the case of the turret machine gun and just within that limit (0.046%) in the case of the bow machine gun.

(2) Insignificant amounts of carbon monoxide accumulated in the blood of the crew members during firing of both machine guns.

c. Control of gun fumes in the M5A1 is at present adequate.

4. RECOMMENDATIONS:

a. Present ventilation of the M5A1 be considered adequate for control of gun fumes.

b. This tank should not be fired with the tank engine dead and the hatches closed.

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1 - Appendix

2 - Tables 1, 2, 3

RESULTS.

1. 37mm gun: A complete trial was carried out in test 1. Six bursts were fired, blood samples were taken and the standard series of continuous and instantaneous air samples were collected. In tests 2 and 3 only 2 bursts were fired and sampling was limited to snap samples and use of the Mine Safety Appliance (MSA) CO indicator. In all cases exposure to both ammonia and carbon monoxide was well within safe limits. Table 1 gives the resulting concentrations of carbon monoxide. Table 3 records carbon monoxide concentrations in the bloods taken from the crew members; insignificant increases were found. Only small amounts of ammonia were found in the air samples taken at the loader's position at the end of the bursts, ranging from 20 to 60 ppm. No complaints were made by the crew members of irritation by ammonia.

2. Machine guns: As judged by these trials ventilation at the turret machine gun is better in the M5A1 than at the bow machine gun. Thus the average concentration of carbon monoxide by continuous sample at the gunner's position during firing of the turret gun was 0.012%, while the air at the breathing zone of the assistant driver during firing of the bow gun averaged 0.046%. See table 2. Corroborating results were secured by the MSA indicator (not shown). Also the ammonia concentration in instantaneous samples taken at the same positions ranged from 40 to 65 ppm at the bow gun while at the turret gun, values of from 20 to 40 ppm were found. In neither case is any hazard likely to be present during these conditions of firing.

TABLE 1

CONCENTRATIONS OF CARBON MONOXIDE FROM 37 MM GUN

Ventilation		Carbon Monoxide Percent
Test 1 Bow Fan on Full Exhaust Bulkhead Ports Closed Engine Idling	Peak Concentration at End of Burst	
	After 1st Burst	0.029
	" 2nd "	0.050
	" 3rd "	0.121
	" 4th "	0.046
	" 5th "	0.062
	" 6th "	0.048
	Average Concentration	
	Loader, by Continuous Sampling	0.017
	Loader, by MSA	0.021
	Asst. Driver, by Continuous Sampling	0.009
	Clearance Rate after last Burst (Time for Conc. to decrease 50%)	14 Seconds
Test 2 Bow Fan Off Bulkhead Ports Closed Engine Idling	Peak Concentration After 2nd Burst	0.033
	Average Concentration Loader, by MSA	0.009
Test 3 Bow Fan On Full Exhaust Bulkhead Ports Open Engine Idling	Peak Concentration After 2nd Burst	0.041
	Average Concentration Loader, by MSA	0.010

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TABLE 2

CONCENTRATIONS OF CARBON MONOXIDE FROM BOW
AND TURRET MACHINE GUNS

	CARBON MONOXIDE PERCENT
TURRET MACHINE GUN	
Peak Concentration at end of Belt (Loader) After 1st Belt	0.033
" 2nd "	0.033
" 3rd "	0.017
Average Concentration by Continuous Sampling Gunner	0.012
Assistant Driver	0.016
BOW MACHINE GUN	
Peak Concentration at end of Belt (Asst. Driver) After 1st Belt	0.032
" 2nd "	0.024
" 4th "	0.029
Average Concentration By Continuous Sampling Asst. Driver (Gunner)	0.046
Driver	0.009
Loader	0.013

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TABLE 3

CARBON MONOXIDE CONCENTRATIONS IN BLOOD OF CREW MEMBERS

Crew Member	CO Hemoglobin as % of Total		
	Before Exposure	After Exposure	Increase
37 Mm Gun			
Loader	3.8	7.2	3.4
Gunner	0.2	2.0	1.8
Driver	---	3.3	---
Asst. Driver	0.5	0.8	0.3
Turret Machine Gun			
Loader	5.1	5.1	0.0
Gunner	4.7	4.5	0.0
Asst. Driver	3.8	6.1	2.3
Bow Machine Gun			
Asst. Driver	6.1	8.2	2.1
Driver	---	2.6	---
Loader	2.2	2.2	0.0

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