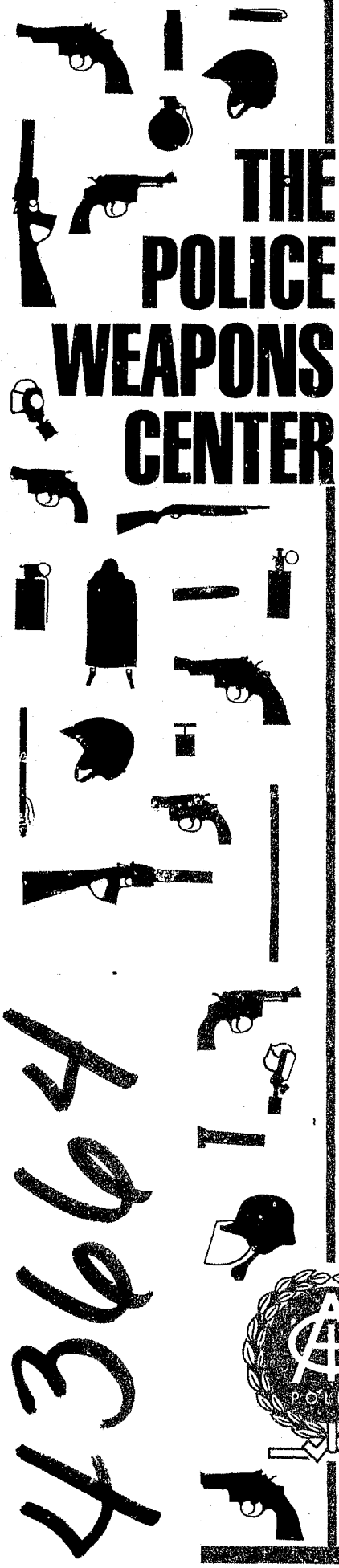

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SPECIAL SUMMARY REPORT ON

THE TOXICOLOGY OF CN, CS, AND DM

INTERNATIONAL ASSOCIATION OF CHIEFS OF POLICE

RESEARCH DIVISION ☐ POLICE CASUALTY ANALYSIS UNIT

11 FIRSTFIELD RD. GAITHERSBURG, MD. 20760

TELEPHONE (301) 948-0922

Special Summary Report on

THE TOXICOLOGY OF CN, CS, AND DM

Prepared by

Directorate of Medical Research

US Army Edgewood Arsenal

CHEMICAL RESEARCH AND DEVELOPMENT LABORATORIES
Edgewood Arsenal, Maryland

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RESUME:

IRRITANT ACTION OF CN, CS, AND DM IN MAN

CN (α - chloroacetophenone), CS (o-chlorobenzylidenemalononitrile), and DM (10-chloro-5, 10-dihydrophenarsazine) act directly on the mucous membranes to produce irritation, burning, and pain in the eyes, nose, throat, and respiratory tract. The action on the eyes also causes lacrimation (tear flow), blepharospasm (tightly closed eye lids), and conjunctivitis (redness of the eyes). The effects in the air passages and lungs causes sneezing, coughing, salivation, congestion of the nose and wall of the pharynx, and a feeling of suffocation.

These effects are noted immediately and they persist 5 to 20 minutes after removal from the contaminated atmosphere. Table 1 shows a comparison of the intolerability of these compounds in man.

TABLE 1

EFFECT OF RIOT CONTROL AGENTS ON MAN

Concentration		Agent		
Minimum	Maximum	DM	CN	CS
mg/m^3		No. of men deciding the agent was intolerable within 30 seconds		
2	10	0/10	0/4	2/15
11	20	0/11	0/1	3/6
21	50	0/4	0/8	10/10
51	100	0/1	0/24	12/12
101	360	–	3/12	–
		No. of men deciding the agent was intolerable within 120 seconds		
2	10	0/10	0/4	6/15
11	20	1/11	1/1	5/6
21	50	0/4	2/8	10/10
51	100	1/1	3/24	12/12
101	360	–	9/12	–

SYSTEMIC EFFECTS OF DM

In addition to the irritant action, DM produces systemic effects. These are headache, perspiration, chills, nausea, vomiting, intestinal cramps, and a feeling of depression, malaise, and "miserableness." These effects start about 30 minutes after the beginning of the exposure and they persist for several hours.

ICt50's* FOR MAN

CN

There is some question concerning the exact ICt50 of CN. An ICt50 of 80 mg min/m^3 was established in 1922. The dispersion technique was to cause drops of a CN solution to fall from a flask onto a hot-plate. This vaporized the solvent and agent. Much of the agent would convert to solid aerosol particles while the solvent remained as a vapor. The atmosphere was not analyzed for CN; the amount of airborne material was estimated by subtracting the final weight of the flask from its original weight.

In 1957 an ICt50 of 213 mg min/m^3 was obtained by dispersing CN from an acetone solution without heat. The airborne material was analyzed by a spectrophotometric technique.

Data from England also indicated that the ICt50 value might be more than 80 mg/m^3 for an exposure time of 1 minute. Recently it has been suggested that an interim value of 150 mg min/m^3 be accepted for the ICt50 of CN for man.

Tests in September 1965, when the compound was dispersed in cold acetone spray and spectrophotometric analysis was used, yielded an ICt50 of about 40 mg/m^3 for exposures of 1 minute or less. The ICt50 for men exposed to CN dispersed from the #112 Spedeheat Grenade (Federal Laboratories, Inc., Saltsburg, Pa.) was 20mg/m^3 for 1 minute or less.

CS

The ICt50 value of 10 to 20 mg/m^3 for a 1-minute exposure is a reasonable estimate. Numerous exposures during the past 5 years indicate that this range is not too high and that the lower value of 10 mg/m^3 may be more realistic than is 20 mg/m^3.

DM

There are still some doubts as to the exact value for the ICt50 for DM as an *irritant*. The value of 22 mg/m^3 for a 1-minute exposure was established on the basis of research in 1922. Alcoholic solutions of DM were dropped into a heated tube and the resulting cloud was conducted into a mixing chamber by a stream of nitrogen. The men breathed the cloud through a mask connected to the chamber by tubing. The concentrations of DM were estimated nominally.

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*"ICt50" means the Concentration x time of exposure that will Incapacitate 50% of an exposed population. C is expressed in mg/m^3; t is expressed in minutes. Thus, Ct (the product of concentration times time of exposure) is expressed in mg min/m^3.

Results of field tests in the early 1920's indicated that the value of 22mg/m^3 might be too low. Also research at CRDL in 1958 indicated that men could tolerate concentrations of 22 to 92 mg/m^3 of DM for 1 minute or more. In the earlier studies the men were not told to resist the agent to their maximum capacity but to terminate the exposure at time of discomfort.

The discrepancy has not been resolved. No human tests have been performed on men using DM munitions. An interim value of 150 mg min/m^3 has been suggested as the LCt50 for DM irritant effects.

Adequate data are not available on the ICt50 for *systemic* effects of DM. There has been a reluctance to perform such research in the past because the need for the information did not justify the possible hazard to the volunteers involved in the test.

EFFECTS AND CAUSE OF DEATH ASSOCIATED WITH LETHAL EXPOSURE TO CN, DM, AND CS

Death occurred in one of 22 men exposed to DM while asleep in an Army barracks. The victim was trapped inside and his exposure lasted 5 to 30 minutes, according to different reports.

Four deaths associated with CN are described in the medical literature. All four resulted from police action against individuals who were in enclosed spaces.

No deaths have been attributed to CS.

A considerable body of data is available on deaths in animals following exposure to CN, CS, or DM.

All of the data on deaths associated with CN and DM reveal that the most prominent signs (rales, rhonchi, dyspnea, chest pain, shortness of breath) and the pathological lesions (edema, congestion, hemorrhage of lungs, pseudomembrane formation, pneumonia, etc.) are related to damage of air passages and lungs.

CN as an aerosol, in very high dosages, may be more damaging to the eyes and skin than DM or CS.

LCt50's* OF CN, CS, AND DM

All the LCt50's are composite values for inhalation toxicities of the various types of aerosol dispersions (agent melted and sprayed in the molten form, dispersed as a dry powder,

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*"LCt50" means the Lethal airborne Concentration times time of exposure that will kill 50% of an exposed population, and is expressed in mg min/m^3.

sprayed from solutions in acetone or methylene dichloride which are nontoxic solvents, agent dispersed from grenades by liberation of hot gases) in 2 to 8 animal species. Prior to the research on CS in 1958-59, no toxicity studies were performed using munitions. All CN and DM munition studies were done in 1965. It has been a generally consistent finding that the munition-dispersed agents are less toxic than those dispersed by some of the other methods. Because of this finding, separate estimates for munitions are now prepared.

In previous calculation of the LCt50 for CS, only data on molten agent in mice, rats, guinea pigs, rabbits, dogs, and monkeys were used. The LCt50 value was 25,000 mg min/m^3. Data on molten CS in the more resistant goats, sheep, swine, and burros were ignored. For some of these species the number of animals was small. However, when data on the resistant animals are included with that on the more susceptible animals, the LCt50 for molten CS is increased to 299,733 mg min/m^3.

The LCt50 for CS dispersed from methylene dichloride is 1,230,497 mg min/m^3 for mice, rats, guinea pigs, and rabbits combined.

The LCt50 value of 79,000 mg min/m^3 for CS dispersed from munitions is based on only two species and one of these, the guinea pig, appears to be especially sensitive to the lethal effect.

Summaries of the LCt50 doses for the various species and the combined species as affected by the various dispersions are shown in Table 3. These data show that CS has the lowest lethality and the highest safety factor of any of the three irritant compounds.

SAFETY FACTOR FOR IRRITANTS (LCt50/ICt50)

Possible safety factors (the ratio between the lethal and the incapacitating [irritating]) dose for man are shown in Table 2.

CONCLUSIONS

1. By all indications, CS is the most effective (acts at lowest dosage) and the least toxic (requires largest absolute dose to kill) of the three irritants.

2. The safety factors between the irritant doses and the lethal doses are greater for CS than for CN or DM.

3. DM may have a persistent action not shared by CN or CS. However, the doses required for this action and the safety factor between the systemically effective doses and the lethal doses for DM have not been firmly established.

TABLE 2

RIOT CONTROL CHEMICAL AGENTS

	CN	CS	DM
Potency (irritant) (LCt50-mg min/m^3	Pure 40-150 (80) [a]Grenade #112 20	10-20 (Same)	22-150 (22)
Toxicity (Lethal) (LCt50-mg min/m^3)	Pure 8,000 (11,000) [a]Grenade #112 14,000	Pure Molten 300,000 (25,000) Pure Solvent 1,200,000 [b]Grenade M7 79,000	Pure 13,000(14,000) [c]Grenade # 113 36,000 dGrenade M6A1 44,000
Safety Factor (LCt50/ICt50)	Pure 200-53 (138) [a]Grenade #112 700	Pure Molten 30,000-15,000 (2,500-1,250) Pure Solvent 120,000-60,000 [b]Grenade M7 7,900-3,950	Pure 590-87 (637) [c]Grenade # 113 1636-240 [d]Grenade M6A1 2000-293
Pathology (deaths) (documented in man)	4 deaths - CN alone 22 deaths - CN-DM mix	No deaths.	1 death - DM alone 22 deaths - CN-DM mix

Values inclosed in brackets represent old estimates made prior to 1965.

a. Designation - No. 112 Federal Spedeheat tear gas (CN) Grenade. Mfg., Federal Laboratories, Saltsburg, Pa. (Grenade components would not be divulged by manufacturer).

b. M18, experimental munition.

c. Designation - No. 113 Federal Spedeheat Sickening Gas (DM) Grenade. Mfg., Federal Laboratories, Saltsburg, Pa. (Grenade components would not be divulged by manufacturer).

d. Standard Army riot control munition.

TABLE 3

SUMMATION OF INHALATION TOXICITIES OF CN, CS, & DM (All Sources)

Species	Dispersal System														
	Pure CN-Molten Dust Spray 1918-1959			Pure CN-10% Acetone 1965 only			No. 112 CN Spedheat Grenade (Fed. Lab.)			CS Molten			CS-Methylene Dichloride		
	No. Anim.	LCt50	Slope	No. Anim.	LCt50	Slope	No.Anim.	LCt50	Slope	No. Anim.	LCt50	Slope	No. Anim.	LCt50	Slope
	mg min/cu m			mg min/cu m			mg min/cu m			mg min/cu m			mg min/cu m		
1. Mouse	-	-	-	-	-	-	-	-	-	120	41,790	3.7	66	626,571	1.88
2. Rat	190	8,878	1.13	140	9,547	0.7	120	23,332	5.2	70	32,293	3.6	160	1,004,427	1.02
3. Guinea Pig	106	7,984	3.56	160	13,355	0.5	120	15,399	1.9	70	8,410	2.3	120	45,838	2.21
4. Rabbit	62	7,033	2.68	48	5,842	2.0	36	15,773	3.4	20	17,452	12.9	32	> 47,000	-
5. Dog	-	-	-	30	5,633	8.4	30	16,515	3.2	36	33,551	2.1	-	-	-
6. Monkey	-	-	-	30	17,542	0.9	30	11,145	9.1	31	50,089	0.8	-	-	-
7. Swine	-	-	-	30	4,384	2.5	48	5,482	2.2	4	> 86,000	-	-	-	-
8. Goat	-	-	-	30	2,462	1.5	36	15,157	3.9	16	> 104,000	-	-	-	-
9. Burro	-	-	-	-	-	-	-	-	-	4	> 61,000	-	-	-	-
10. Sheep	-	-	-	-	-	-	-	-	-	4	Ca 64,000	-	-	-	-
11. Pigeon	-	-	-	-	-	-	-	-	-	24	32,121	6.2	24	644,207	1.43
12. Chickens	-	-	-	-	-	-	-	-	-	16	> 49,000	-	-	-	-
13. Sick Goats	-	-	-	-	-	-	-	-	-	16	> 104,000	-	-	-	-
14. Sick Monkeys	-	-	-	-	-	-	-	-	-	-	-	-	18	30,000	-
Combination of Species	2,3,4	6,189	1.86	2-8	8,435	0.24	2-8	14,204	2.2	1-6 1-6,7,8.9,10	25,000 300,000	4.2 0.21		1,230,497	0.24

*Combined LCt50 value (6 species) used as basis for old human estimate for CS slope.
**Combined LCt50 value (10 species) to be basis for new human estimate for CS.

TABLE 3 - Continued

Species	Dispersal System																	
	CS M18 Grenade			CS Acetone			Pure DM Molten Dust Spray 1918-1965			Pure DM Acetone 1965 Only			DM M6A1 Grenade 1965			DM No. 113 Spedeheat Grenade		
	No. Anim.	LCt50	Slope	No. Anim.	LCt50		No.Anim.	LCt50	Slope	No. Anim.	LCt50	Slope	No. Anim	LCt50	Slope	No. Anim.	LCt50	Slope
		mg min/cu m			mg min/cu m			mg min/cu m			mg min/cu m			mg min/cu m			mg min/cu m	
1. Mouse	-	-	-	-	-		114	46,245	0.6	-	-	-	-	-	-	-	-	-
2. Rat	79	163,832	2.25	-	-		580	13,478	0.8	180	22,900	5.9	180	66,856	3.8	220	48,217	3.8
3. Guinea Pig	80	36,439	2.0	50	>35,000		342	7,091	1.2	100	4,625	2.2	120	12,591	3.3	220	29,888	4.6
4. Rabbit	-	-	-	-	-		-	-	-	-	-	-	48	41,159	1.9	78	46,959	5.2
5. Dog	-	-	-	-	-		102	13,944	2.7	30	7,889	5.0	35	28,193	7.2	30	28,428	5.0
6. Monkey	-	-	-	-	-		76	13,886	1.0	36	17,837	12.5	30	19,569	3.5	30	22,814	5.2
7. Swine	-	-	-	-	-		30	56,361	2.4	30	56,361	2.4	30	36,011	2.1	30	35,888	9.9
8. Goat	-	-	-	-	-		29	12,072	4.4	29	12,072	4.4	30	8,076	1.3	48	11,723	2.2
9. Burro	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
10. Sheep	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
11. Pigeon	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
12. Chickens	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
13. Sick Goats	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
14. Sick Monkeys	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
Combination of Species	2-3	78,778	1.7	-	-		1,2,3, 5,6,7, 8	13,158	0.9	2,3 5,6 7,8	12,187	1.7	2,3,4 5,6,7,8	43,809	1.0	2,3,4 5.6.7 8	34,683	3.0

THE TOXICOLOGY OF CN

TOXICITY STUDIES OF CN IN ANIMALS

Inhalation toxicity studies in mice and dogs were carried out in 1918. Studies on mice, rats, and guinea pigs were done in 1958-1959. In these studies the CN was dispersed by sublimation, as dry dust, and from solvents. In 1965, studies were performed in rats, guinea pigs, rabbits, dogs, monkeys, swine, and goats. The CN was dispersed from acetone solvent or from the # 112 Spedeheat thermal grenades manufactured by the Federal Laboratories, Inc. of Saltsburg, Pennsylvania.

The data on mice in the older studies were so highly variable that statistical analysis indicated that higher doses were less lethal than lower doses. The data on mice were rejected from consideration.

ANIMAL EXPOSURE AND OBSERVATION TIMES

The exposure times ranged from 3 to 160 minutes and the observation periods were one to two weeks in the 1918 studies, 2 weeks in the 1958-1959 tests, and 4 weeks in the 1965 studies.

TOXICOLOGICAL SIGNS IN ANIMALS

The signs produced by CN were similar by all methods of dispersion. During exposure the signs noted were: lacrimation, conjunctivitis, salivation, frothing at the mouth and nose, erythema and swelling around the eyes, genitalia and arms; dyspnea; hyperactivity followed by hypoactivity and death. Erythema was prominent on the abdomen and inner legs of the dogs and swine. After exposure all species exhibited dyspnea for 1 to 24 hours. Conjunctivitis and erythema persisted for about 3 to 7 days. The goats appeared emaciated at this time.

TOXIC DOSES FOR CN (1918-1959)

The toxicity data for inhaled CN, dispersed by thermal sublimation, as dry dust, or from solvents is as follows:

	No. of Animals	LCt50	Slope
Rats	190	8878	1.1
Guinea Pigs	106	7984	3.6
Dogs	62	7033	2.7
All Three Combined	358	6189	1.9

The LCt50's for CN dispersed from acetone (1965) in rats, guinea pigs, rabbits, dogs, monkeys, swine, and goats were 9500, 13,000, 5800, 5600, 18,000, 4400, and 2500, mg min/m^3, respectively.

REPEATED EXPOSURES TO CN (#112 SPEDEHEAT GRENADE)

Twenty guinea pigs and eight monkeys were exposed on 10 consecutive days to Ct's ranging from 2300 to 4000 mg min/m^3 of CN. These daily doses are 5 to 12 LCt's for guinea pigs but below the dose expected to kill any of the monkeys. The total accumulated Ct was 31,445 mg min/m^3. This dose would be expected to kill about 70% of the guinea pigs and all of the monkeys, if given in one exposure. Three guinea pigs died on the ninth day, and one each died on the tenth and twenty-first day after the first exposure. No more guinea pigs and no monkeys died during the 30-day experimental period. Thus, the number of deatns is less than would be expected if the total dose (Ct of 31,000 mg min/m^3) had been given in a single dose.

Eight dogs were exposed 10 consecutive days to Ct's ranging from 3000 to 7000 mg min/m3 of CN. These daily Ct's might be expected to kill up to 12% of the dogs. The total accumulated Ct was 60,000. This would be expected to kill most of the dogs if given in one exposure. One dog died on the twenty-second day of experiment. No other deaths occurred during the 30-day experimental period. The death could have been expected from one of the 10 exposures. The number of deaths did not approach that which would be expected if the total dose had been given during one exposure.

Twenty guinea pigs, 8 dogs, and 8 monkeys were exposed on 10 consecutive days to Ct's ranging from 4200 to 13,000 mg min/m^3. These doses would be expected to kill 13-49% of the guinea pigs, 3-38% of the dogs, and 0-70% of the monkeys. The total accumulated Ct was 88,000 mg min/m^3. Had this dose been given in one exposure almost all the animals of all 3 species would be expected to die. The death rates among all 3 species were somewhat lower than would be expected for the largest single dose. None of the death rates approached those which would be expected from the total accumulated dose, assuming that this dose were given in one exposure.

Thus, there was little evidence of cumulative toxicity in any of these experiments.

LOCAL APPLICATION OF CN TO RABBITS' EYES AND SKIN

CN suspended in corn oil and placed in rabbit eyes caused no noticeable effect in doses of 0.5 mg CN, transitory conjunctivitis at 1.0 mg, and corneal opacity in doses of 5.0 mg per eye.

CN in corn oil produced erythema and necrosis of the skin of some rabbits in doses of 5 mg of agent.

PATHOLOGY FOLLOWING INHALATION OF CN IN ANIMALS

Pathological findings in animals that died following exposure to aerosols of CN reveal the following:

Dogs - Congestion, edema, emphysema of the lungs, membranous tracheitis, bronchitis, bronchopneumonia.

Rats, Mice, Guinea pigs - Pulmonary congestion, edema, bronchopneumonia, occasional hemorrhage in adrenals.

CAUSE OF DEATH IN ANIMALS

The primary cause of death is attributable to the lung damage.

LETHALITY OF CN IN MAN

Five deaths have occurred in men following exposure to CN in inclosed spaces. All exposures were the result of police action. A. A. Stein and Kirwan[1] give this description of one case.

"On admission to the hospital the patient was agitated and under restraints. His clothes and body smelled of tear gas. His temperature was 99°F.; pulse 80; respirations 24; blood pressure 130/80. The conjunctiva were suffused. The pupils were small and unreactive. There was an abundance of mucoid discharge from both the nose and the mouth. By auscultation the chest was clear. However, the heart had an irregular rhythm. The cardiogram was interpreted as within normal limits but with occasional premature ventricular contractions. The neurological examination was unremarkable except for the absence of the Babinski reflex.

He remained in a semicomatose condition for approximately 12 hours and then suddenly developed pulmonary edema and died."

PATHOLOGY OF CN IN MAN

Pathology noted in men dying after exposure to CN includes the following:

Gross examination - Mucosa of trachea and bronchi swollen. Edema of the lungs. Intra-alveolar hemorrhage. Petechiae in the stomach.

Microscopic examination - Necrosis of the respiratory mucosa with formation of pseudomembrane. Congestion, swelling, edema, and inflammatory cell infiltration of the submucosa. Desquamation of the bronchioles. Pseudomembrane formation. Congestion of the alveolar capillaries. Bronchopneumonia.

CAUSE OF DEATH FOLLOWING CN EXPOSURES IN MAN

The cause of death following CN exposures in man have been attributed to damage to the respiratory system as follows:

Medical Authority	Stated Cause of Death
Gonzales[2]	Secondary bronchopneumonia from inflammation of air passages.
Stein[1]	Acute pulmonary edema

ESTIMATES OF EFFECTIVENESS, LETHALITY AND SAFETY FACTORS OF CN IN MAN

ICt50

Technical manual 3-215, Military Chemistry and Chemical Agents, Dec. 1963, p 34, states the following: "Median incapacitating dosage, 80 mg min/m^3."

The value of 80 mg min/m^3 is for a 1-minute exposure taken from EACD 108.[3] This dosage was calculated from data which appeared in EACD 130.[4] Solutions of CN were dispersed by dropping the material on a hot-plate. The Ct values were derived nominally. The ICt50 value as reported in EACD 130 was 35 mg min/m^3 for a one-minute exposure. Data on human exposures, which were given in TM 24-18,[5] 1 Nov 1958, indicate that the ICt50 for a 0.5-2.0 minute exposure would be greater than 80 mg min/m^3.

The ICt50 values calculated from these data (TM 24-18) and reported by C.L. Punte, *et al.*[6] were 213, 119 and 93 mg min/m^3 for exposures of 1, 2 and 3 minutes, respectively. D. Crichton, *et al.*[7] (these data are also reported in TM 24-18) states: "at relatively high concentration of 2 ppm, CN produces lachrymation and some blepharospasm, which begins to decrease in severity when the exposure has lasted longer than about 3 minutes. Subjects have remained in an atmosphere of 2 ppm for 8 minutes without distress and could have remained longer." This statement was repeated as follows by Trouern-Trend and Crichton:[8] "Observers were incapacitated after 40 seconds exposure to a concentration of 7.8 mg/m^3 of [CS] (Ct = 5.2 mg min/m^3) but were not incapable of activity after 8 minute exposure to a concentration of 14.7 mg/m^3 of CN = 116 mg min/m^3)."

Recently it has been suggested that an interim value of 150 mg min/m^3 be accepted for ICt50 of CN for man. Further tests were conducted during the latter part of September 1965 and at the present writing it is indicated that the ICt50's are as follows:

ICt50's FOR CN IN MAN

Dissemination Type	No. of Men Responding	Time to Response	ICt50 mg min/m^3
Acetone Spray	10/17	9-40 Sec.	40
# 112 Spedeheat Grenade	10/17	15-43 Sec.	20

LCt50

TM 3-215 gives the following: "Median lethal dosage. No exact data but believed to be about 11,000 mg min/m^3." C.A. Ransom and F.B. Bogart,[9] gave the lethal concentration for dogs for ½ hour exposure as 0.34 mgm per liter. Wells and Eldridge[10] quote the minimal lethal concentration for CN as 0.85 mg/liter for a 10-minute exposure. The same paper gives data and states that the minimal lethal concentration for mice is 0.04 mg/liter for a 300-minute exposure. No chemical analysis of the airborne material was performed. NDRC Informal Monthly Progress Report No. 9-4-1-2[11] shows deaths in 0/20 and 12/20 mice after 10-minute exposures at concentrations of 0.66 and 2.56 mg/liter of CN. An LCt50 of 800 mg min/m^3 and an MLD of 400 mg min/m^3 for mice was given by Gongwer, *et al.*[5] Punte, *et al.*,[12] reported LCt50's of 3700, 73,500 and 3500 mg min/m^3 for rats, mice and guinea pigs, respectively.

The above data made difficult the derivation of a human estimate for the LCt50 for inhaled CN, and occasioned the TM 30215 statement of "no exact data" on lethal dosage.

For the purposes of the present report, all available original data were obtained for studies conducted from 1918 to 1965. These data were analyzed by the method of Bliss and regression lines were calculated. This information is shown in Tables 1-4 of the appendix and it is discussed in the section on lethality of inhaled CN in animals. The combined toxicity data for "pure" CN dispersed from molten agent, dry dust, or solvent systems and inhaled by rats, guinea pigs, rabbits, dogs, monkeys, swine, and goats (832 animals) for studies from 1918 to 1965, yields an LCt50 of 8163 mg min/m^3. The slope of the regression line is 2.3. The LCt50 for CN dispersed from the # 112 Spedeheat grenade in 420 animals (rats, guinea pigs, rabbits, dogs, monkeys, swine and goats) was 14,204 mg min/m^3. The slope of the regression line was 2.2. It is suggested that LCt50's of 8000 and 14,000 mg min/m^3 be accepted for CN dispersed in the "pure" form and by thermal grenades (with burning characteristics of the # 112 Spedeheat), respectively.

SAFETY FACTORS FOR INHALED CN

On the basis of data presented in this report the best safety values for inhaled CN are as follows:

Agent	LCt50	ICt50	Safety Factor LCt50/ICt50
	mg min/m^3		
"Pure" CN	8000	40	200
# 112 Spedeheat Thermal Grenade	14,000	20	700

LIST OF REFERENCES

1. Stein, A.A. and W.E. Kirwan. Chloroacetophenone (Tear Gas) Poisoning: A Clinico-Pathologic Report. J. of Forensic Sci: 9, 374-382 (1964).

2. Gonzales, Thomas A., *et al.* Legal Medicine, Pathology and Toxicology. Appleton-Century-Crafts, Inc., New York, New York. 1954.

3. Pierce, H.S. and M.G. Witherspoon. A Digest of Reports Concerning Toxic Effects of Chloroacetophenone. *Edgewood Arsenal Chemical Division 108.* Feb 28, 1922.

4. Carlton, E.A. and R.E. Morse. Chloroacetophenone. Tolerance Test on Man. *Edgewood Arsenal Chemical Division No. 130.* April 11, 1922.

5. Gongwer, L. E., *et al.* CWL Tech Memo 24-18. The comparative effectiveness of Four Riot Control Agents. 1 Nov. 1958.

6. Punte, C. L., *et al.* Inhalation Studies with Chloroacetophenone, Diphenylaminochloroarsine and Pelargonic Morpholide - II. Human Exposures. Am. Indus. Hyg. Assoc. J. 23, 199-102 (1962).

7. Crichton, D., W/CDR, M.A.P. Hagg and P.J.R. Bryand and G.J. Lewis. Agents for Riot Control – The Selection of T.792 (O-Chloro-Benzal Malononitrile) as a Candidate Agent to Replace CN. Porton Technical Paper No. 651. Oct 1958.

8. K. Trouren-Trend and D. Crichton. Demonstration of the Relative Effectiveness of T.792 and CN as Riot Control Agents. Great Britain Port Demo 1/57. May 1957.

9. Ransom, C.A. and F.B. Bogart. Chloroacetophenone - Toxicity on Dogs. War Dept Chemical Warfare Service Res Div. Am Univ Exp Sta, Wash., D. C. BM Report XXVI, Report No. 91, 737-742, Aug 22, 1918.

10. Wells, William J.H.B. and W.A. Eldridge. Minimal Lethal Concentrations of Certain Lachrymatory Compounds for Mice for Five Hour Exposures. Edgewood Arsenal Medical Research Division Report 76 (1927).

11. National Defense Res Committee of the Office of Sci Res and Dev. Div 9. (NDRC) Informal Monthly Progress Report on Toxicity of Chemical Warfare Agents. Tox Lab, Univ of Chicago.

12. Punte, C. L., Ballard, T.A. and J.T. Weimer. Inhalation Studies with Chloroacetophenone, Diphneylaminochloroarsine and Pelargonic Morpholide - I. Animal Exposures. Am. Indus. Hyg. Assoc. J. 23, 194-198 (1962).

THE TOXICOLOGY OF CS

TOXICITY STUDIES OF CS IN ANIMALS

Toxicity determinations were conducted in healthy mice, rats, guinea pigs, rabbits, dogs, monkeys, goats, swine, sheep, burros, pigeons and chickens. In addition, goats and monkeys suffering from respiratory diseases were included in the toxicity studies. The goats were rendered pneumonic by injecting them with 50 mg/kg of cortisone to lower their resistance to infection and 24 hours later introducing Pasteurella multocida or bovine kidney tissue into the trachea. The sick monkeys were suffering from pulmonary tuberculosis or chronic pulmonary tularemia.

DISSEMINATION OF THE CS AEROSOLS

In the toxicity studies the CS was disseminated by four methods:

1. Spraying the molten agent.
2. Spraying of 10% solution of CS in methylene dichloride.
3. Spraying of 5% solution of CS in acetone.
4. Dispersion from the M18 thermal grenade.

ANIMAL EXPOSURE TIMES AND OBSERVATION PERIODS

The exposure times ranged from 5 to 90 minutes and the observation period were at least 14 days in all species.

TOXICOLOGICAL SIGNS IN ANIMALS

Immediately upon exposure the mouse, rat, guinea pig, rabbit, dog, and monkey became excitable and hyperactive. Copious lacrimation and salivation occurred within 30 seconds in all of the above species except the rabbit. After 5 to 15 minutes the excitement was supplanted by lethargy and dyspnea. This continued for about one hour after exposure. All other signs subsided within 5 minutes after removal from the contaminated atmosphere. The goat, pig, sheep, and burro showed few signs of excitement in the presence of the agent. In a given species the toxicological signs were similar for all dispersion methods.

TOXIC DOSES OF CS DISPERSED FROM METHYLENE DICHLORIDE

LCt50 values in mice, rats, and guinea pigs for CS dispersed from methylene dichloride solution were 627,000, 1,005,000 and 46,000 mg min/m^3, respectively. No deaths occurred in rabbits which were exposed 4 each at Ct's of 1,000; 10,000; 12,000; 13,000; 15,000; 33,000; and 47,000.

The combined LCt50 for CS dispersed from methylene dichloride for mice, rats, guinea pigs, and rabbits was 1,230,000 mg min/m^3.

The LCt50 for pigeons was 644,207 mg min/m^3.

CS at Ct's up to 30,000 mg min/m^3 did not kill any of 18 monkeys with pulmonary tularemia.

The data are shown in Table 5 of the appendix.

TOXIC DOSES FOR MOLTEN CS

The LCt50 doses for CS sprayed from the molten agents were 42,000 32,000, 8,500, 17,000, 34,000, 50,000, and 32,000 mg min/m^3 for mice, rats, guinea pigs, rabbits, dogs, monkeys, and pigeons, respectively. LCt50 values could not be calculated for swine, sheep, burros, and goats. Two swine per dose survived Ct's of 65,000 and 86,000 mg min/m^3. Two sheep survived at a dose of 30,000 mg min/m^3 and one of two died at a Ct of 64,000 mg min/m^3.

The combined LCt5C for mice, rats, guinea pigs, rabbits, dogs, monkeys, swine, sheep, goats and burros was 300,000 mg min/m^3.

The toxicity data are shown in Table 6 of the appendix.

TOXIC DOSES OF CS DISPERSED FROM ACETONE

The only study conducted using acetone as a solvent was performed with guinea pigs. The LCt50 for this species was greater than 35,000 mg min/m^3. Thus, acetone and methylene dichloride dispersions of CS appeared to have similar toxicities in guinea pigs.

The data are shown in Table 2.

TOXIC DOSES OF CS FROM THE M18 THERMAL GRENADE*

The LCt50's for CS dispersed from the M18 thermal grenade in rats, guinea pigs, and both species combined were 164,000, 36,000, and 79,000, respectively.

The toxicity data are shown in Table 7 of the appendix.

CHRONIC TOXICITY OF CS IN RATS AND DOGS

Thirty rats and 4 dogs were exposed to thermally dispersed CS from 4 to 5 minutes per day, 5 days per week, for 5 weeks. The 25-day cumulative Ct to which the dogs were exposed was 17,000 mg min/m^3 (the daily Ct was about 680 mg min/m^3). The 25-day cumulative Ct for the rats was 91,000 mg min/m^3 and the daily Ct was about 3640 mg min/m^3. The rats struggled vigorously during inhalation of this agent, biting the noses and tails of other rats or scratching their own noses. About one-third of the rats had bloody noses by the end of the exposures. There were

*M7-type experimental munition.

no changes in blood values of sodium, potassium, proteins, albumin, or creatinine throughout the tests. Five rats died, two following cumulated Ct's of 25,000 mg min/m^3 and 3 others after 68,000 mg min/m^3. Gross pathological examinations of these rats were negative as were those of 6 others that were sacrificed after 5 weeks. The exposed rats lost about 1% of their body weight while unexposed animals gained about 20% during the 5 weeks. There was no significant difference in organ-to-body weight ratios for heart, kidney, lungs, liver of spleen following the 5-week exposure.

It is indicated that repeated exposure did not make the animal more sensitive to the lethal effects of CS.

LOCAL APPLICATION OF CS TO RABBIT EYES

Doses of 5 and 10 mg of CS from a 10% solution in methylene dichloride placed in rabbits' eyes caused immediate conjunctivitis, which disappeared in a few hours. There was no corneal damage. A dose of 50 mg of CS in a 50% suspension in methylene dichloride did not produce corneal or other damage in the eyes of any of 10 rabbits. The eyes were treated daily with sodium sulfamyd to prevent secondary infection. The observation period was 14 days.

PATHOLOGY AND CAUSE OF DEATH

Animals dying after exposure to CS show increased numbers of goblet cells in the respiratory tract and conjunctive, necrosis in the respiratory and gastrointestinal tract, pulmonary edema, and occasionally hemorrhage in the adrenals.

Death appears to result from the poor transfer of oxygen from the lungs to the blood stream, probably because of the edema, hemorrhage in the lung, and obstruction in the air passages.

HUMAN STUDIES ON CS

BASIC DOSE-RESPONSES - SPEED OF ACTION REGRESSION LINES

Healthy, adult men were exposed to CS in a wind-tunnel at temperatures of 43° F to 80°F and relative humidity of 30% to 80%. The usual ambient temperatures and humidity were about 65°F and 30%, respectively. The agent was sprayed as a 5% solution in acetone into an airstream that flowed at 5 mph. The men breathed at a normal rate while standing facing the wind stream. They were instructed to resist the agent and to remain in the tunnel as long as possible. They were told to emerge from the tunnel of their own volition. The time when the man could no longer tolerate the agent and he was forced to leave the tunnel was considered to be the incapacitation time. Regression lines were developed for 146 human exposures. These lines are shown in Figure 1 of the appendix. The incapacitating signs in men were intense burning in the eyes, nose, and respiratory tract, profuse lacrimation, salivation, blepharospasm, tightness in the chest, and a feeling of suffocation.

THE INFLUENCE OF VARIABLES ON THE TIME TO INCAPACITATION

No significant difference from the data contained in Figure 1 for time to incapacitation could be shown:

a. For CS dispersed from a minature M18 grenade.

b. For men exposed at 0°F.

c. For men over 50 years of age or for those having medical histories of allergies, hypertension, jaundice, or hepatitis.

The time to incapacitation was the same or shorter than shown in Figure 1 when exposures were performed at 95°F, 35% relative humidity and at 95°F, 97% relative humidity.

LETHALITY OF CS IN MAN

CS has not been implicated in human deaths.

THE TOXICITY ESTIMATES FOR MAN

The combined LCt50 for mice, rats, guinea pigs, rabbits, dogs, and monkeys was used as the estimate for men, despite the fact that this value ignores the more resistant swine, goats, sheep, and burros.

THE SAFETY FACTOR FOR CS

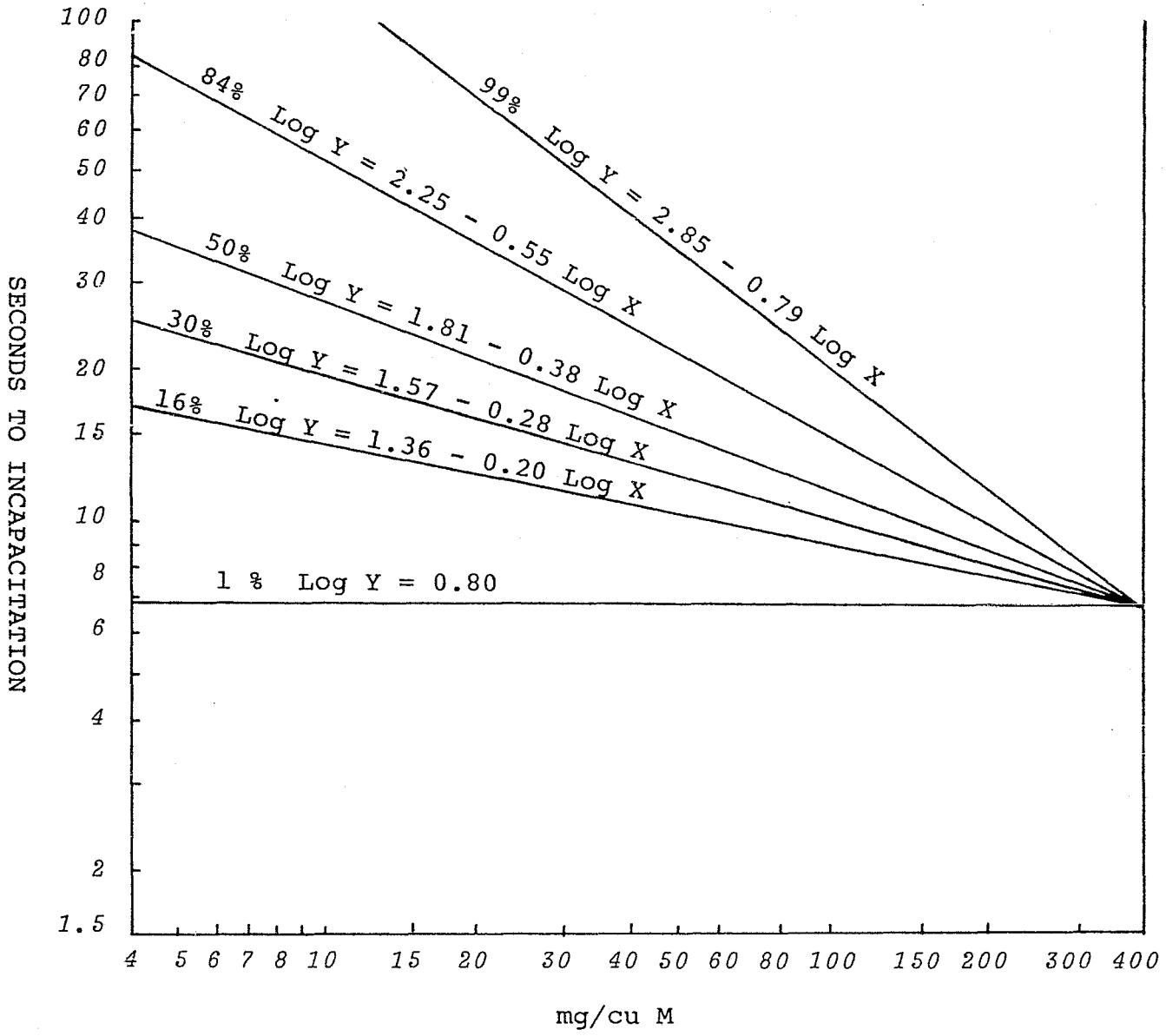
Based upon the ratio between the combined LCt50 value for mice, rats, guinea pigs, rabbits, dogs, and monkeys of 25,000 mg min/m^3, and the ICt50 value in man of 10-20 mg min/m^3, the safety factor is 1250 for CS dispersed as the molten agent. When the data for goats, sheep, swine, and burros are added, the combined LCt50 is 300,000 mg min/m^3 and the safety factor is 15,000.

Based upon the LCt50 for the M18 munition in rats and guinea pigs, the safety factor is 3900.

Based upon the combined data for mice, rats, rabbits, and guinea pigs, the LCt50 for CS dispersed from methylene dichloride is 1,230,497 mg min/m^3 and the safety factor is 61,500.

FIGURE 1

TIME TO INCAPACITATION OF UNTRAINED MEN WITHOUT MASKS WITH CS



THE TOXICOLOGY OF DM

TOXICITY STUDIES OF DM IN ANIMALS

One of the striking features of inhalation toxicity studies on DM is the variation in results of different experiments. The British "Red Book", 1940,* declined to quote toxicity values for this compound in animals because of the inconsistencies of results. Possibly, the methods of dispersion of the aerosols and the methods for measuring airborne concentrations contributed to the variabilities.

The data used in this report include dispersions of molten DM to dogs (1918), dry dust dispersions to mice, rats, and guinea pigs (1957), acetone dispersions to mice, rats, guinea pigs, dogs, and monkeys (1963-1964), acetone, and munition (M6A1 thermal grenade, #113 Spedeheat thermal grenade) dispersions (1965). The LCt50 values are shown in Tables 8, 9, 10, and 11. These tables also show the exposure times and observation period of the animals.

TOXICOLOGICAL SIGNS IN ANIMALS

The signs were similar for all types of dispersions and were as follows:

Mice, Rats, Guinea Pigs.

Immediately upon exposure the animals were hyperactive. Within a few minutes lacrimation and salivation were observed. After 5 to 15 minutes the excitement was generally supplemented by lethargy and labored breathing. The latter signs often persisted for 1 or 2 hours after exposure. The other signs usually subsided within 5 to 10 minutes after removal of the animals from the contaminated atmosphere.

Dogs.

Immediately upon exposure the dogs became extremely restless. Jumping and barking were noted. Salivation, retching and vomiting occurred. The animals became ataxic and some were unable to maintain standing posture. Upon removal from the chamber they were hypoactive, they pawed their faces; gagging and vomiting occurred periodically for 24 hours. They consumed little food or water and, for about 7 days, they appeared emaciated. After 7 days the animals resumed normal eating and drinking and improved in appearance. Most deaths occurred in the first week after exposure.

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*Chemical Defense Res Dept Rpt on the Chemistry and Toxicology of Certain Compounds. The British "Red Book" - 1940.

Monkeys.

During exposure, salivation, vomiting, rhinorrhea, ataxia, and difficulty of breathing was noted. Upon removal from the chamber the animals exhibited wheezing, ptosis and lethargy. Coughing and vomiting persisted for about 24-48 hours. After 24-48 hours, open lesions were noted on the face and around the eyes, possibly due to pawing by the animal. Prior to death the monkeys lay face down, and breathing seemed to be depressed.

Goats.

Signs which occurred during exposure were hyperactivity, shaking of the head, rearing on the hind legs, licking, chewing, frothing at the mouth, ataxia, convulsions, bloating, and some died.

During the week following exposures the animals were hypoactive, knelt on their forelegs. gagged, and vomited. The goats seemed weak. They collapsed and convulsed prior to death. All goats were bloated upon death.

Swine.

The signs noted during exposure were salivation, frothing at the mouth, ataxia, and irregular breathing. During the first 14 days after exposure the pigs had breathing difficulty, lost weight, appeared emaciated, and some died.

TOXIC DOSES FOR DM

The combined data for "pure" DM (dry dust, molten agent, solvent dispersion) in 1273 animals (mice, rats, guinea pigs, dogs, monkeys, swine, and goats) exposed from 1918-1965 yields an LCt50 of 13,158 mg min/m^3.

The combined LCt50 for the same species for DM (acetone dispersion) studies performed in 1965 only was 12,187 mg min/m^3.

Combined LCt50's for 473 animals (rats, guinea pigs, rabbits, dogs, monkeys, swine, and goats) exposed to the M6A1 thermal grenade, or for 656 animals (same species) exposed to the # 113 Spedeheat thermal grenade of Federal Laboratories, Inc., were 43,809 and 34,683 mg min/m^3, respectively.

The LCt50's for the separate species are shown in Tables 8, 9, 10, and 11.

REPEATED EXPOSURES TO DM

Monkeys, dogs, and guinea pigs were exposed on 10 consecutive days to DM aerosols (# 113 Spedeheat thermal grenade). The daily doses were approximately at the LCt5 level. A similar groups of animals were exposed at approximately the LCt 20-25 level on each of 10 days. In both cases the accumulated doses would be expected to kill all animals were the total doses given in a single exposure.

The lower dose level killed 5/8 monkeys. This is more than would be expected from any one of the exposures alone; this is a lower mortality than would have been expected of the total accumulated dose. The deaths among the dogs and guinea pigs at the low dose level was not greater than would have been expected from any of the single exposures and far less than would be expected of the accumulated dosage.

The deaths in monkeys and guinea pigs at the higher dosage level is slightly greater than would have been expected for the maximum single dose. The deaths in dogs were less than that which would have been expected of the maximum single dose. There was little indication of cumulative toxicity due to the repeated exposures. The data are shown in Table 12.

LOCAL APPLICATION OF DM TO RABBIT EYES AND SKIN

A suspension of DM in corn oil was administered intraocularly to groups of 6 rabbits each at dose levels of 0.1, 0.2, 0.5, 1.0 and 5.0 mg per eye. All animals were observed from 8 to 14 days. A dose level of 0.1 mg produced no noticeable signs; 0.2 mg produced a transitory conjunctivitis; 0.5 mg caused a transitory conjunctivitis and blepharitis; 1.0 and 5.0 mg produced corneal opacity which persisted during the 14-day period.

Suspensions of DM in corn oil were placed upon the clipped skin of rabbits. Dose levels of 1, 10, 50, 75 and 100 mg per animal were administered to groups of 6 rabbits each. Doses of 10 mg and above produced necrosis.

PATHOLOGY FOLLOWING INHALATION OF DM IN ANIMALS

Pathological findings in animals that died following inhalation of DM include the following:

Dogs.

Hyperemia of the larynx and trachea. Edema and congestion of the lung. Bronchopneumonia.

Rats, Mice.

Atelectasis, emphysema, reticular cell proliferation, respiratory epithelial proliferation, interstitial leucocytic inflitration of the bile duct.

Monkeys.

Pneumonitis, ulcerative bronchiolitis and tracheitis, edema and congestion of the lungs.

Guinea Pigs.

Bronchitis, tracheitis.

CAUSE OF DEATH IN ANIMALS

The primary cause of death is lung damage.

INCAPACITATING EFFECTS OF DM IN MAN

The onset of signs from DM may be almost immediate or may be delayed several minutes. The initial effects are irritation; a burning sensation and pain in the eyes, nose, throat and respiratory tract; uncontrollable cough; violent and persistent sneezing; lacrimation and copious flow of saliva. The conjunctiva, nose, and pharyngeal wall become congested. The signs of irritation subside after 20 to 30 minutes. Headache, depression, perspiration, chills, nausea, abdominal cramps, vomiting, and diarrhea may appear in about 30 minutes after exposure and persist for several hours.

ICt50 OF DM IN MAN

There is controversy as to the ICt50 for irritant effects of DM in man.

A dose-effect graph for intolerable concentrations of DM was developed by Lawson and Temple* in 1922 and included concentrations of 22.3, 0.7, 0.2, and 0.14 mg/m^3 for exposure periods of 1, 5, 15 and 60 minutes, respectively. It is likely that the median incapacitating doses of 22 mg min/m^3 for a 1-minute exposure, and 8 mg min/m^3 for a 60-minute exposure, as reported in TM 3-215, Dec 1963, Military Chemistry and Chemical Agents, page 32, were derived from the graphs of Lawson and Temple.

In this test an alcoholic solution of DM was dropped into a heated tube and the cloud produced was conducted into a mixing chamber by a stream of nitrogen. The men breathed the cloud through a 1919-type mask connected to the chamber by a 3-way valve. The concentrations of DM were estimated nominally. Subjects were told to keep on the mask until there was a feeling of distress, but due to the nature of the gas, they were not expected to fight it to the limit of their endurance.

*W. E. Lawson and B.W. Temple. Report on Relation Between Concentration and Limit of Tolerance for Diphenylaminechloroarsine and the Development of Continuous Flow Apparatus for Testing. EAC'D 92, 25 Jan 1922. Recalculated and reported in EACD 145.

Results of field tests during the early 1920's indicated that same observers tolerated Ct's of DM of 83 to 155 mg min/m^3. Although the quantitative aspects of these field exposures are somewhat doubtful, there appears to be some discrepancy between the doses of Lawson and Temple and those measured in the field.

Other human exposures at CRDL in 1958 indicated that men could tolerate concentrations of 22 mg/m^3 to 92 mg/m^3 for 1 minute or more. In the latter tests the subjects were told to resist the agent.

An interim ICt50 of 150 mg min/m^3 has been suggested for DM.

SYSTEMIC EFFECTS

An important consideration concerning DM is the persistent incapacitating effect. These effects include malaise, depression, nausea, and vomiting. However, the required dosages and the frequency of occurrence of these signs are a matter of question. In the studies of 1922, nausea occurred in 3 of 21 men at concentrations of 2 mg/m^3 after exposures of 140 seconds to 15 minutes (Ct's 4.6 - 30 mg min/m^3) and in 2/23 men exposed at concentration levels of 5 mg/m^3 for periods of 45 seconds to 12½ minutes (Ct's 3.75 - 62.5 mg min/m^3).

Lawson and Temple indicated a low frequency of systemic effects in their studies. "Delayed effects were infrequent, an occasional dull headache persisting for several hours, and in one case, where the concentration was 0.06 mg/liter (60 mg/m^3) a man was incapacitated for work for 2 days with stomach trouble, dull headache, and general depression." A few other cases were found where stomach trouble was caused by gas, due, in the writer's opinion, to individual susceptibility.

In the human studies of 1958, systemic efforts were seen infrequently. Nausea was noted in 2 of 25 men exposed at Ct's of 18-22 mg min/m^3. The Ct range for all 25 exposures was from 5 to 144 mg min/m^3. Eighteen exposures were at Ct's greater than 22 mg min/m^3.

LETHALITY OF DM IN MAN

One death has been attributed to inhalation of DM. This followed the operation of a DM generator in a barracks exposing 22 sleeping men. The estimated concentration was 1130-2260 mg/m^3. The exposure period was 5 or 30 minutes, according to different reports. The Ct's would be 5650-11,300 mg min/m^3 for the 5-minute exposure and 33,900-67,800 mg min/m^3 for the 30-minute exposure.

Post mortem examination of the victim revealed emphysema of the subcutaneous tissues of the neck, the mediastinum, pleura, and pericardium. Emphysematous bullae were scattered over the lungs. The lungs were springy and grossly crepitant. Areas of what appeared to be bronchopneumonia patches with a bluish discoloration were noted. No consolidation, edema, or casts in the bronchi were noted when the lung was cut.

Histological study showed edema and congestion of the epiglottis, superficial ulceration and acute diffuse inflammation of the trachea and bronchi, false membrane formation in the trachea and bronchi, lung congestion, edema, and hemorrhage, and bronchopneumonia.

CAUSE OF DEATH FOLLOWING INHALATION OF DM BY MAN

Death can be attributed to damage to the lungs and respiratory system.

LCt50 DOSES OF DM FOR MAN

An estimate for the toxicity of inhaled DM in man was established at CRDL in 1959. This estimate used toxicity data on mice and guinea pigs reported in TM 24-18, and data on dogs reported in EACD 145.* All of the toxicity data were combined to yield a composite lethality dose-response graph for "mammals" including man. The LCt50 for a single exposure was 14,000 mg min/m^3.

More recent studies have greatly increased the number of animals and species. The LCt50's for "pure" DM (dispersed as molten agent, dry dust, or from solvent) in mice, rats, guinea pigs, dogs, monkeys, swine, and goats are shown in Tables 8, 9, 10, and 11. The combined LCt50 for "pure" DM in these 1273 mammals was 13,158 mg min/m^3.

Similar data for DM dispersed from the M6A1 thermal grenade and from the #113 Spedeheat thermal grenade are also shown on these tables. The combined LCt50's for the two munitions in "mammals" are 43,809 and 34,683 mg min/m^3, respectively. Until 1965 no DM munitions had been studied for inhalation toxicity. It is to be noted that the toxicities are similar for the two munitions and that both produce aerosols that appear less toxic than those produced from "pure" DM.

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*A Digest Report on Diphenylamine-Chloroarsine - EACD 145. April 29, 1922, pp 11-22.

SAFETY FACTORS FOR INHALED DM

On the basis of data presented in this report the best safety factors for inhaled DM are as follows:

AGENT	LCt50	LCt50	Safety Factors LCt50/ICt50
	mg min/m^3		
"Pure" DM	13,000	22 or 150	590 or 87
M6A1 Grenade	44,000	22 or 150	2000 or 293
#113 Spedeheat Grenade	36,000	22 or 150	1636 or 240

APPENDIX

Tables 1 through 12

TABLE 1

INHALATION TOXICITY OF CN (10% in Acetone - Wt/Vol) IN SEVEN ANIMAL SPECIES
(30-Day Observation)

Species	Ct	Concentration	Exposure Time	Mortality	Times to Death	Statistical Analysis P	ED50	Lower	Upper	Standard Error of slope
	mg min/cu m	mg/cu m	min		hrs					
Monkey	29,790	259	115	5/6	18,24,96 (3)*	1	1,380	15	130,944	.89
	18,100	201	90	2/6	24,120	16	5,916	1121	31,223	
	12,200	203	60	2/6	18,240	30	9,890	4549	21,499	
	6,300	210	30	1/6	68	50	17,542	7338	41,939	
	4,520	226	20	1/6	216	84	522,017	2817	960,503	
						99	222,994	647	76,902,480	
Dog	17,370	217	80	6/6	18 (6)	1	4,410	2657	7,318	8.37
	6,300	210	30	5/6	18 (3), 20, 44	16	5,073	4066	6,330	
	5,300	147	36	2/6	24,72	30	5,331	4658	6,101	
	4,520	226	20	0/6		50	5,633	4097	6,227	
	2,700	208	13	0/6		84	6,255	4798	8,154	
						99	7,196	4137	12,516	
Swine	17,370	217	80	6/6	1,18(4),44	1	1,717	80	36,520	2.48
	7,640	191	40	5/6	16 (3), 17, 72	16	2,937	653	13,202	
	5,700	190	30	6/6	18,48,90,162,408(2)	30	3,549	1355	9,295	
	4,550	152	30	2/6	335,600	50	4,384	2937	5,545	
	3,550	197	18	2/6	18,288	84	6,545	2687	15,941	
						99	11,193	983	127,416	
Goat	17,370	217	80	6/6	18 (4), 120 (2)	1	305	3.2	28,715	1,509
	12,210	222	55	5/6	19 (3),72, 96	16	1,008	0.1	14,502	
	7,640	191	40	2/6	216 (3), 218,264,336	30	1,537	210.2	11,245	
	5,700	190	30	6/6	115,168,264,272,408 (2)	50	2,462	738.3	8,211	
	3,550	197	18	3/6	120,264,268	84	6,015	3,209	11,271	
						99	19,890	3,411	115,964	
Rabbit	31,035	282	110	6/6	2 (2), 18 (4)	1	2,579	1,163	5,718	2.009
	20,160	310	65	6/6	18 (6)	16	4,118	2,714	6,250	
	11,300	249	45	6/6	19 (6)	30	4,859	3,609	6,540	
	10,160	203	50	6/6	18,24,28,72,96 (2)	50	5,842	4,782	7,138	
	7,645	191	40	4/6	72,216,384 (2)	84	8,287	6,185	11,105	
	6,300	210	30	3/6	18,48,72	99	13,236	6,882	25,456	
	5,300	147	36	2/6	336 (2)					
	4,375	175	25	2/6	144,216					
Rat	31,035	282	110	20/20	18 (20)	1	2,939	1,613	5,357	.70
	20,160	210	65	19/20	18 (18), 36 (1)	16	5,769	4,389	7,584	
	11,200	249	45	16/20	19 (8), 38 (5), 67 (1), 70 (1), 168 (1)	30	7,320	6,135	8,735	
						50	9,547	8,353	10,910	
	10,160	203	50	8/20	18 (4), 172(2), 96(1), 120 (1)	84	15,797	11,617	21,481	
						99	31,008	16,392	58,657	
	7,645	191	40	2/20	18 (1), 72 (1)					
	6,300	210	30	5/20	20 (2), 44 (1), 68 (2)					
	4,375	175	21	3/20	240 (3)					

* Number in parenthesis indicates number of animals which died at the given times.

Table 1. continued (Inhalation Toxicity of CN in Seven animal species)

Species	Ct	Concentration	Exposure Time	Mortality	Times to Death	Statistical Analysis P	ED50	Lower	Upper	Standard Error
Guinea Pig	34,910	218	160	20/20	24(2), 28 (2), 48 (5) 72 (2), 96 (3), 98 (1), 120 (4), 144 (1)	1	3,743	1,883	7,445	.537
						16	7,754	5,302	11,339	
						30	10,026	7,581	13,260	
						50	13,355	11,090	16,082	
	31,935	282	110	19/20	2(2), 18 (10, 36 (4), 42 (1), 60 (1), 91 (1)	84	23,001	18,834	28,091	
						99	47,637	29,552	76,790	
	29,235	217	135	19/20	8 (2), 72 (3), 96 (2), 120 (4), 144 (6), 126 (1), 216 (1)					
	24,225	211	115	20/20	72 (1), 96 (1), 122(7), 124 (1), 158(8), 216(2)					
	20,160	310	65	12/20	36 (1),54 (1), 91 (1), 94 (1), 384 (8)					
	11,120	249	45	3/20	165 (3)					
	6,300	210	30	3/20	144 (2), 456					
	3,700	148	25	1/20	288					
All Rodents (rat and g.p)						1	2,764	1,712	4,463	.352
						16	6,131	4,826	7,790	
						30	8,123	6,885	9,583	
						50	11,116	9,925	12,449	
						84	20,152	16,488	24,629	
						99	44,701	28,919	69,095	
Non-Rodent						1	617	130	2,933	.442
						16	2,166	997	4,706	
						30	3,374	2,027	5,617	
						50	5,533	4,293	7,131	
						84	14,137	8,711	22,942	
						99	49,645	14,174	173,882	
All Species Combined						1	1,268	655	2,452	
						16	3,752	2,723	5,168	
						30	5,502	4,466	6,779	
						50	8,435	7,507	9,478	
						84	18,965	14,818	24,271	
						99	56,125	31,389	100,354	

TABLE 2

CN ACUTE INHALATION TOXICITY (No. 112 Federal Spedeheat Grenade)

Species	Ct	Concentration	Exposure Time	Mortality	Times to Death	Statistical Analysis						
						P	ED(P)	Lower Limit	Upper Limit	Probit Y(-)	Log x (+)	Standard Error
	mg min/cu m	mg/cu m	min		hrs							
Monkey (Macaca Rhesus)	36,100	4,011	9	6/6	14 (6)*	1	6,173.4	1,278.0	29,819.9	31.7	9.07	3.91
	12,550	2,092	6	4/6	21 (4)	16	8,675.5	5,363.4	13,974.9			
	8,470	1,694	5	1/6	552 (1)	30	9,755.2	8,140.3	11,690.4			
	6,189	1,547	4	0/6	–	50	11,144.7	10,566.3	11,754.6			
	2,700	675	4	0/6	–	84	14,346.3	5,225.3	39,388.2			
						99	20,119.2	2,511.2	161,188.3			
Dog	43,392	2,669	14	6/6	19 (5), 48 (1)	1	3,056.4	620.0	15,066.8	8.39	3.18	.95
	36,100	4,011	9	4/6	2 (1), 14 (2), 98 (1)	16	8,029.1	3,526.5	18,280.5			
	12,550	2,092	6	4/6	21(1), 48(1), 54(1), 78(1)	30	11,290.9	6,172.9	20,652.3			
	8,470	1,694	5	0/6	–	50	16,515.4	10,225.3	28,675.8			
	2,700	675	4	0/6	–	84	33,971.1	15,727.3	73,377.9			
						99	89,241.1	19,275.0	413,175.3			
Goat	26,139	2,354	9	6/6	18 (6)	1	3,776.1	1,090.7	12,073.1	11.1	3.85	1.17
	25,086	2,826	8	3/6	16 (2), 48 (1)	16	8,367.2	4,508.1	15,529.9			
	17,475	2,496	7	5/6	18 (1), 336 (3), 624 (1)	30	11,080.2	7,196.6	17,059.6			
	14,126	2,354	6	2/6	48 (1), 114 (1)	50	15,156.7	11,073.1	20,746.2			
	7,700	1,540	5	1/6	72 (1)	84	27,455.5	15,700.9	48,010.3			
	4,700	1,175	4	0/6	–	99	60,837.1	18,807.8	196,788.6			
Swine	26,139	2,354	9	6/6	18 (6)	1	490.0	5.2	46,234.2	3.30	2.22	.75
	17,475	2,496	7	6/6	18 (5), 24 (1)	16	1,952.8	210.3	18,135.6			
	14,126	2,354	6	2/6	19 (1), 144 (1)	30	3,181.2	763.8	13,249.1			
	7,700	1,540	5	5/6	17 (3), 24 (1), 312 (1)	50	5,482.9	2,973.6	10,109.9			
	6,189	1,547	4	5/6	22 (1), 48 (3), 72 (1)	84	15,394.9	3,900.7	60,759.6			
	4,700	1,175	4	3/6	72 (1), 106 (1), 587 (1)	99	61,349.9	1,563.6	2,407,215.2			
	4,080	1,360	3	3/6	72(1), 106 (1), 587 (1)							
	3,800	950	4	0/6	18(1), 72 (1), 163 (1)							
Rabbit	55,650	3,975	14	6/6	2 (2), 4 (3), 18 (1)	1	3,282.8	373.6	28,844.3	9.33	3.41	1.16
	36,100	4,011	9	6/6	24 (1), 38 (1), 48 (1)	16	8,063.1	2,356.3	27,591.2			
					65 (1), 89 (1), 168 (1)	30	11,072.7	4,443.2	27,593.4			
	32,866	2,892	10	5/6	3 (4), 24 (1)	50	15,773.0	8,695.5	28,611.2			
	25,086	2,826	8	3/6	18 (3)	84	30,855.2	18,637.2	51,082.9			
	12,550	2,092	6	3/6	168 (1), 192 (1), 240(1)	99	75,784.4	19.980.5	287,443.8			
	2,700	675	4	0/6	–							

TABLE 3
INHALATION TOXICITIES OF CN IN VARIOUS ANIMAL SPECIES, 1918-1959

Species	Source	Date	C	t	Ct	Obs Period	Mort	Time to Death	P	ED(P)	Lower	Upper	Slope	Remarks
			mg/cu m	min	mg min/cu m	days								
Dog	Gavin	7/6/18	60	30	1800	9-10	0/2							
	Crandall,		64		1920		0/2							
	Marlow		180		5400		2/2	53 hr. 64 hr	1	722	23	22891		Analytical concentration
	BM XXVI-91		240		7200		4/4	29 hr, 49.5 hr	16	2048	291	14392		
			370		11100		2/2	43 hr, 48 hr	30	2959	698	12535		
			380		11400		0/2		50	4461	1745	11403	2.94	
			577		17310		2/2	21 hr, 21 hr	84	9718	4306	21936		Thermal dispersion of CN
			610		18300		2/2	1 hr, 26 hr	99	27571	3224	235755		dissolved in benzol
			730		21900		2/2	18 hr, 18 hr						
			1090		32700		2/2	20 min, 25 min						
			1140		34200		2/2	15 min, 19 min						
			1330		39900		2/2	15 min, 24 min						
Dog	Ransom	8/22/18	150	30	4500		1/2	11 da	1	1045	64	17120		Analytical concentration
	&		190		5700		1/2	48 hr	16	3566	1152	11037		
	Bogart		210		6300		0/2		30	5499	3462	8734	2.5	
	BM XXVI-91		260		7800		0/2		50	8915	5676	14002		CN heated to 115° C
			270		8100		1/2	10 da	84	22288	7365	67449		
			280		8400		2/4	48 hr, 7 da	99	76031	4741	1219206		
			320		9600		1/2	24 hr						
			325		9750		1/2	36 hr						
			340		10200		1/2	48 hr						
			345		10350		2/2	24 hr, 36 hr						
			380		11400		0/2							
			410		12300		2/2	48 hr, 6 da						
			430		12900		1/2	3 da						
			470		14100		2/2	48 hr, 48 hr						
Dog	RPGilbert	6/25/18	30*	30	900		0/1		Not applicable					Analytical concentration
	&		110*		3300		1/1	24 hr	"					
	HHJohnson		170*		5100		0/1		"					*Alcohol Spray
	BM XXII-76		170*		5100		0/1		"					
			80**		2400		0/1		"					**Heat vaporization
			50**		1500		0/1		"					

INHALATION TOXICITIES OF CN IN VARIOUS ANIMAL SPECIES, 1918-1959

TABLE 3 (Cont'd)

Species	Source	Date	C	t	Ct	Obs Period	Mort	P	ED(P)	Lower	Upper	Slope	Remarks
			mg/cu m	min	mg min/cu m	days							
Guinea Pig	Aerosol Branch	11/28/58	53	15	793	14	0/6						Pneumatic dust dispersion Colorimetric (m-dinitro-benzene)
			154	15	2303		0/6			N/A			
			107	15	1600		0/6						
			127	15	1904		0/6						
			129	15	1935		0/6						
			97	15	1486		0/6						
Guinea Pig	Aerosol Branch	7/19/59	330	5	1650	14	2/10	1	505	182	1400	2.78	Acetone spray - colorimetric
			270	7	1890		3/10	16	1520	845	2735		
			330	15	4950		5/10	30	2242	1417	3546		
			315	30	9450		10/10	50	3459	2420	4944		
			515	20	10310		8/10	84	7873	5232	11846		
			337	45	15180		10/10	99	23689	10761	52116		
All Dog,	Gavin, et al	July 1918						1	350	119	1032	1.86	All types of dispersions
Rat, Guinea Pig Com-bined	Ransom, et al	Aug 1918						16	1812	1141	2876		
	Gilbert, et al	June 1918						30	3238	2475	4238		
	Rat-Aerosol Br	Aug 1958						50	6189	5121	7479		
		Sep 1958						84	21139	12036	37128		
	G. Pig-Aerosol Br	Nov 1958						99	109521	33360	359557		
		July 1959											

TABLE 3 (Cont'd)

INHALATION TOXICITIES OF CN IN VARIOUS ANIMAL SPECIES, 1918-1959

Species	Source	Date	C	t	Ct	Obs Period	Mort	Time to Death	P	ED(P)	Lower	Upper	Slope	Remarks
			mg/cu m	min	mg min/cu m	days		days						
Rat	Aerosol Branch	8/14/58	148	15	2220	14	2/10	141	1	837	1.7	497573	2.0	
		8/18/58	332	15	4985		6/10	1(3)*,3(3)	16	3810	2033	7141		UV-268 millimicron in $ChCl_3$ Molten CN Spray
		8/19/58	494	15	7409		6/10	9(6)	30	6506	2085	20304		
			198	15	2970		1/10	2	50	11819	423	330329		
			311	15	4668		1/10	10	84	36664	22	61516640		
			350	15	5255		0/10		99	166978	0.4	66674225000		
			279	15	4178		0/10							
			343	15	5145		0/10							
Rat	Aerosol Branch	9/16/58	354	5	1771	14	6/6	6 hr	1	431	193	963	6.99	UV-268 millimicron in $ChCl_3$ Pneumatic dust dispersion
		9/17/58	51	15	771		4/6	< 1	16	668	485	920		
			46	15	696		1/6	?	30	780	635	959		
			43	15	645		0/6	-	50	927	729	1178		
			66	15	990		2/6	?	84	1286	730	2267		
									99	1994	680	5849		
Rat	Aerosol Branch	7/19/59	404	5	2020	14	0/10	-						Acetone Colorimetric spray
			367	10	3670		0/10	-	1	1480	399	5482	3.23	
			370	17	6290		7/10	-	16	3824	2057	7109		
			496	15	7440		4/10	-	30	5347	3587	7969		
			472	20	9440		7/10	-	50	7770	6101	9896		
			702	18	12626		5/10	-	84	15788	9103	27383		
			441	30	13240		10/10	-	99	40799	11868	140258		
			851	35	29776		9/10	-						

*Number in parenthesis indicates number of animal deaths on given day.

TABLE 4

INHALATION TOXICITY OF 10 DAILY EXPOSURES TO CN (# 112 Spedeheat Grenade)

Day	Daily Ct	Cumulative Ct	Deaths G. Pig	Deaths Monkey	Daily Ct	Cumulative Ct	Deaths Dog	Daily Ct	Cumulative Ct	Deaths G. Pig	Deaths Dog	Deaths Monkey
	mg min/cu m	mg min/cu m			mg min/cu m	mg min/cu m		mg/min/cu m	mg min/cu m			
1	3883	-	0/20	0/8	6665	-	0/8	6815	-	1/20	0/8	0/8
2	3372	7255	-	-	4846	11511	-	9024	15839	2/20	-	0/8
3	2335	9590	-	-	5890	17401	-	10770	26609	2/20	-	1/8
4	2828	12418	-	-	5320	22721	-	4200	30809	2/20	-	1/8
5	3980	16398	0/20	-	6950	29671	-	8160	38969	2/20	-	1/8
6	3373	19771	0/17	-	5937	35608	0/8	10347	49316	2/19	-	1/8
7	2342	22113	0/17	-	5876	41484	0/7	6127	55443	2/19	0/8	1/8
8	3605	25718	0/17	-	7062	48546	-	13020	68463	3/19	1/8	2/8
9	3159	28887	3/17	-	6630	55176	-	10561	79024	3/19	1/8	3/8
10	2558	31445	4/17	0/8	4387	59563	0/7	9464	88488	3/19	1/8	4/8
11	-	-	-	-	-	-	-	-	-	-	2/8	-
21	-	-	5/17	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	1/7	-	-	-	-	-
30	-	-	5/17	0/8	-	-	1/7	-	-	3/19	2/8	4/8

ACUTE LETHAL Cts FOR CN (#112 Spedeheat Grenade)

Guinea Pig		Dog		Monkey	
P	mg min/cu m	P	Mg min/cu m	P	mg min/cu m
1	972	1	3056	1	6173
16	4727	16	8029	16	8676
30	8261	30	11291	30	9755
50	15399	50	16515	50	11145
84	50163	84	33971	84	14346
99	243907	99	89241	99	20119

TABLE 5

CS INHALATION TOXICITY (Dispersed from 10% solution in Methylene Dichloride)

Species	Source	Concentration	Exposure Time	Ct	Deaths*	Day of Deaths	Statistical Analysis P	ED(P)	Lower Limit	Upper Limit	Slope
		mg/cu m	min	mg/min/cu m							
Mice	CWLR	900	10	9,000	0/20	–	1	36,380	5,633	234,947	
	2360	1,650	20	33,000	0/20	–	16	185,581	37,939	907,787	
	Feb 1960	2,566	30	77,000	1/20	5(1)**	30	329,8	14,880	7,311,963	1.88
		2,625	40	105,000	0/20	–	50	626,571	5,712	68,732,744	
		2,200	50	110,000	1/4	5(1)	84	2,115,471	980	4,567,549,900	
							99	10,791,251	95	12,239,918,100,000	
Rats	CWLR	500	4	2,000	0/10	–	1	5,350	99	288,736	
	2360	800	5	4,000	0/10	–	16	107,146	3,681	3,118,801	
	Feb 1960	570	7	4,000	0/10	–	30	308,612	704	135,235,260	1.02
		500	10	5,000	0/10	–	50	1,004,427	115	8,777,741,300	
		538	13	7,000	0/10	–	84	9,145,852	4	23,499,228,000,000	
		1,125	8	9,000	0/10	–	99	188,560,190	.04	xxxxxxxx	
		1,100	10	11,000	1/10	4(1)					
		1,500	12	18,000	0/10						
		1,267	15	19,000	1/10	5(1)					
		1,350	20	27,000	1/10	4(1)					
		2,455	11	27,000	0/10	–					
		2,055	18	37,000	1/10	7(1)					
		1,433	30	43,000	1/10	8(1)					
		1,343	35	46,000	0/10	–					
		1,178	45	53,000	1/10	12(1)					
		1,967	30	59,000	1/10	5(1)					
Guinea Pig	CWLR	600	5	3,000	0/10	–	1	4,060	1,921	8,581	
	2360	500	6	3,000	0/10	–	16	16,262	10,952	24,146	
	Feb 1960	800	5	4,000	0/10	–	30	26,541	16,975	41,497	2.21
		455	11	5,000	0/10	–	50	45,838	25,097	83,719	
		538	13	7,000	0/10	–	84	129,202	47,438	351,900	
		700	10	7,000	0/10	–	99	517,561	105,049	2,549,947	
		800	10	8,000	0/10	–					
		1,000	10	10,000	2/10	1(1),6(1)					
		917	12	11,000	1/10	1(1)					
		800	15	12,000	0/10						
		509	55	28,000	7/10	1(2),6(5)					
		1,400	60	84,000	5/10	1(1),3(1),5(1),6(2)					
Rabbits	CWLR										
	2360										
	Feb 1960	1,000	10	10,000	0/4	N/A					
		667	15	10,000	"						
		667	15	10,000	"						
		800	15	12,000	"						
		650	20	13,000	"						
		1,000	15	15,000	"						
		1,100	30	33,000	"						
		1.044	45	47,000	0/4						

* 14 Day observation period.

** Number in parenthesis indicates number of animal deaths on given day.

TABLE 5 - continued

Species	Source	Concentration	Exposure Time	Ct	Deaths*	Day of Deaths	Statistical Analysis				
							P	ED(P)	Lower Limit	Upper Limit	Slope
		mg/cu m	min	mg min/cu m							
Pigeons	CWLR	333	15	5,000	0/4	–	1	15,179	2,491	92,476	
	2360	800	10	8,000	0/4	–	16	129,761	17,787	946,614	
	Feb 1960	1,300	20	26,000	0/4	–	30	276,749	71,207	1,075,604	1.43
		1,733	30	52,000	0/4	–	50	644,207	159,333	2,604,631	
		1,571	35	55,000	1/4	3(1)*	84	3,198,198	82,996	123,240,490	
		1,933	45	87,000	0/4	–	99	27,340,416	61,563	12,141,978,000	
All species combined (mammals only)							1	3,047	200	7,484	
							16	94,609	50,524	477,333	
							30	318,120	122,037	6,036,407	.24
							50	1,230,497	305,310	109,395,350	
							84	16,003,983	1,663,606	27,803,867,000	
							99	496,884,700	15,738,627	47,322,570,000,000	

* 14 Day observation period.
** Number in parenthesis indicates number of animal deaths on given day.

TABLE 6

CS INHALATION TOXICITY (sprayed as molten agent)

Species	Source	Concentration	Exposure Time	Ct	Mortality	Day of Deaths*	Statistical Analysis				
							P	ED(P)	Lower Limit	Upper Limit	Slope
		mg/cu m	min	mg/min/cu m							
Mice	CWLR 2360 Feb 1960	1,200	10	12,000	0/20		1	9,899	2,177	45,004	
		1,100	20	22,000	7/20	7(1)**,8(3),9(3)	16	22,578	14,566	34,996	
		900	30	27,000	2/20	7(2)	30	30,205	25,668	35,543	3.72
		800	40	32,000	5/20	5(2),9(3)	50	41,790	26,829	65,093	
		740	50	37,000	5/20	5(1),6(3),7(1)	84	77,350	22,310	268,180	
		683	60	41,000	14/20	5(1),8(5),9(4) 13(1)	99	176,419	17,052	1,825,257	
	REMARKS: Molten dispersion – UV analysis – 260 mμ										
Rats	CWLR 2360 Feb 1960	560	25	14,000	1/10	1(1)	1	7,172	2,611	19,704	
		543	35	19,000	2/10	1(2)	16	16,973	11,257	25,952	
		489	45	22,000	3/10	2(1),3(1),4(1)	30	23,004	17,966	29,454	3.56
		454	55	25,000	5/10	1(3),3(2)	50	32,293	25,265	41,267	
		500	60	30,000	2/10	1(2)	84	61,443	32,551	115,979	
		500	80	40,000	6/10	1(1),2(2),6(3)	99	145,405	41,517	509,249	
		500	90	45,000	8/10	1(1),3(2),7(2), 11(3)					
	REMARKS: As above										
Guinea Pig	CWLR 2360 Feb 1960	400	5	2,000	1/10	7(1)	1	811	168	3,921	
		400	10	4,000	2/10	7(1),8(1)	16	3,095	1,510	6,345	
		400	15	6,000	4/10	1(2),6(2)	30	4,964	3,138	7,854	2.29
		500	20	10,000	3/10	1(1),6(1),7(1)	50	8,410	6,038	11,713	
		400	25	10,000	7/10	2(5),7(1),8(1)	84	22,851	10,448	49,982	
		400	30	12,000	7/10	1(4),5(1),7(1), 9(1)	99	87,154	16,809	451,894	
		425	40	17,000	8/10	1(7), 3 (1)					
	REMARKS: As above										
Rabbits	CWLR 2360 Feb 1960	250	40	10,000	0/4	–	1	11,534	5,230	25,434	
		267	45	12,000	0/4	–	16	14,620	11,820	18,082	
		500	30	15,000	1/4	6(1)	30	15,896	13,297	19,004	12.93
		250	80	20,000	3/4	1(1),2(1),7(1)	50	17,452	14,317	21,272	
		333	90	30,000	4/4	1(1),2(1),3(1), 8(1)	84	20,832	13,714	31,643	
							99	26,406	10,074	69,213	
	REMARKS: As above										
Pigeons	CWLR 2360 Feb 1960	368	19	7,000	0/4		1	13,579	3,656	50,432	
		325	40	13,000	0/4		16	22,229	17,923	27,571	
		511	45	23,000	1/4	5(1)	30	26,454	19,585	35,732	6.22
		300	60	18,000	0/4		50	32,121	26,504	38,928	
		353	80	28,210	3/4	<1(2),1(1)	84	46,413	16,346	131,786	
		600	60	36,000	2/4	5(1),6(1)	99	75,984	9,882	584,243	
	REMARKS: As above										

* 14 day observation period.

** Number in parenthesis indicates number of animal deaths given day.

TABLE 6 - Continued

Species	Source	Concentration	Exposure Time	Ct	Mortality	Day of Deaths*	P	Statistical Analysis ED(P)	Lower Limit	Upper Limit	Slope
		mg/cu m	min	mg min/cu m							
Dogs	Aerosol Br	833	20	16,669	0/4	-	1	2,486	54	113,545	
	1959	508	36	18,276	2/4	5(1),**10(1)	16	11,030	2,750	42,234	
		649	30	19,476	1/4	12(1)	30	18,662	12,860	27,081	2.06
		520	45	23,424	2/4	1(1),2(1)	50	33,551	21,298	52,854	
		612	45	27,536	2/4	1(1),4(1)	84	102,055	14,079	739,760	
		899	40	35,974	2/4	1(2)	99	452,715	5,616	36,491,644	
		797	60	47,828	3/4	1(2), 3(1)					
		909	60	54,530	2/4	1(2)					
	REMARKS: Molten Dispersion - UV Analysis - 260 mμ.										
Monkeys	Aerosol Br.	469	24	11,246	1/4	5(1)	1	43	.04	42,684	
	1959	381	45	17,130	2/4	1(2)	16	2,446	270.0	22,186	
		673	30	20,176	2/4	1(2)	30	10,192	3,636	28,566	0.76
		612	45	27,536	1/4	1(1)	50	50,089	12,092	207,482	
		699	60	41,930	1/4	1(1)	84	1,025,906	29,758	35,367,900	
		941	60	56,459	3/4	1(3)	99	58,511,908	17,775	192,605,810,000	
		1057	60	63,433	2/4	1(2)					
	REMARKS: As above, except MMD=2.0-3.2 μ.										
Pigs	Gassing Br.	2157	30	64,701	0/2	-		N/A			
	1959	1434	60	86,048	0/2	-					
	REMARKS: As above.										
Sheep	Gassing Br.	999	30	29,680	0/2	-		N/A			
	1959	1065	60	63,909	1/2	1(1)					
	REMARKS: As above, except MMD = 3.4 μ										
Burro	Gassing Br	1030	35	36,165	0/2	-		N/A			
	1959	1019	60	61,178	0/2	-					
	REMARKS: As above, except 2.2-3.5 μ.										
Goats	Gassing Br	416	60	24,959	0/4	-		REMARKS: Each group contained two healthy and two sick goats. Goats were made sick by administration of cortisone and infecting with pasturella multocida or bovine kidney tissue virus. Two were suffering from natural infection. Sick goats had temperatures>103°F and rales when exposed to CS. Both goats which died had been artifically infected. - MMD = 3.0 - 6.9 μ.			
	1959	502	60	30,143	0/4	-					
		448	84	37,672	0/4	-					
		672	60	40,330	0/4	-					
		688	60	41,305	0/4						
		994	60	59,624	1/4	3(1)					
		1143	60	68,585	1/4	6(1)					
		1491	70	104,363	0/4						
Chicken	Aerosol Br	2030	5	10,150	1/4	8(1)		N/A			
		2153	10	21,525	0/3	-					
		1999	15	29,985	1/4	13(1)					
		3253	15	48,795	0/4	-					
Combined Species (mammals only)							1	.19	.005	1.7	
							16	677.9	229.07	1,339	
							30	12,071	9,217	14,705	.209
							50	299,733	179,543	673,868	
							84	132,516,170	25,484,556	1,871,782,000	
							99	462,463,170,000	19,066,339,000	77,974,418,000,000	

814 Day observation period.
**Number in parenthesis indicates number of animal deaths on given day.

TABLE 7

CS INHALATION TOXICITY (Dispersed from the M-18 Thermal Grenade)

Species	Source	Concentration	Exposure Time	Ct	Mortality*	Time to Death	Statistical Analysis P	ED (P)	Lower Limit	Upper Limit	Slope
		mg/cu m	min	mg min/cu m		Day					
Rats	CWLR	600	15	9,000	1/10	2(1)**	1	15,207	8,724	26,505	
	2360	454	23	13,000	0/10	–	16	59,301	33,090	106,273	
	Feb 1960	562	32	18,000	0/10	–	30	95,870	26,293	349,558	2.25
		1,350	20	27,000	1/10	2(1)	50	163,832	22,312	1,202,969	
		600	45	27,000	0/10	–	84	452,627	17,193	11,916,132	
		567	60	34,000	0/10	–	99	1,765,098	12,463	249,978,980	
		600	75	45,000	1/10	1(1)					
Guinea Pigs	"	600	15	9,000	0/10	–	1	2,571	181	36,530	
		454	23	13,000	2/10	2(1),3(1)	16	11,730	4,698	29,287	
		562	32	18,000	2/10	1(1),2(1)	30	20,044	13,352	30,090	2.02
		1,350	20	27,000	3/10	3(1),5(1),1(1)	50	36,439	20,165	65,847	
		600	45	27,000	7/10	3(2),4(1),5(3)	84	113,197	17,864	717,282	
						8(1)	99	516,500	13,920	19,164,678,000	
		567	60	34,000	5/10	2(1),4(3),5(1)					
		600	75	45,000	5/10	1(2),2(1),3(1)					
						8(1)					
Rats	"						1	3,209	76	136,203	
							16	20,053	11,868	33,883	
and							30	38,289	16,809	87,218	1.67
							50	78,778	9,744	636,883	
Guinea							84	309,478	3,252	29,450,886	
Pigs							99	1,933,710	738	5,065,875,500	

* = 14 Day observation period.

** = Number in parentheses represents number of animan deaths on day indicated.

TABLE 8

ACUTE DM INHALATION TOXICITY (Solvent System - 10% wt/vol - Acetone)

Species	Ct	Concentration	Exposure Time	Mort	Time to Death	Statistical Analysis P	ED(P)	Lower	Upper	Standard Error
	mg min/cu m	mg/cu m	Min		Hours					
Monkey	40,000	296	135	6/6	28/43/149/190(2)*/248	1	11,604	6,339	21,242	
	25,085	214	117	6/6	43/47/67/148/235/307	16	14,842	10,907	20,196	
	20,800	219	95	4/6	42/65/238/286	30	16,189	13,038	20,101	
	16,720	209	80	3/6	192/278/350	50	17,837	15,351	20,725	
	12,555	279	45	0/6	-	84	21,434	16,740	27,445	
	5,940	297	20	0/6	-	99	27,416	16,050	46,828	4.137
					-					
Dog	16,720	209	80	6/6	10/16/17/35(3)	1	2,709	1,218	6,022	
	12,555	279	45	4/6	18/20/42/116	16	4,995	3,251	7,675	
	9,060	206	44	5/6	63/86/278/336/356	30	6,199	4,450	8,636	
	5,940	297	20	1/6	305 -	50	7,888	5,951	10,457	
	2,960	212	14	0/6	-	84	12,455	8,205	18,908	
					-	99	22,970	10,489	50,297	
					-					
Goat	41,600	210	198	6/6	4/16(2)/72/77/113	1	3,631	990	13,316	1.295
	30,000	227	132	6/6	22(2)/71/95/240/552	16	7,245	3,537	14,840	
	19,640	216	91	4/6	18/90/198	30	9,246	5,376	15,902	
	9,800	233	42	3/6	20(2)/239	50	12,135	8,051	18,292	
	5,062	230	22	0/5	-	84	20,327	12,010	34,401	
					-	99	40,556	13,986	117,603	1.332
Swine	61,000	223	273	3/6	5.5/20/167	1	6,183	154	247,970	
	41,600	210	198	2/6	4/335	16	21,913	7,423	64,686	
	30,000	227	132	2/6	47(2)	30	34,245	19,928	58,847	
	19,640	216	91	1/6	42	50	56,364	16,709	190,140	
	9,900	206	48	0/6	-	84	114,930	6,141	3,420,500	
						99	513,700	1,473	-	1.181
Rat	61,000	223	273	20/20	4/8/20(4)/47(5)/71/95(2)/ 118,(2)/124/147(2)/168	1	12,296	8,708	17,364	
	40,000	296	135	20/20	3(2)/47(2)/120(10)/190(4)/ 216(2)	16	15,887	13,582	13,584	
	25,085	214	117	18/20	29/110(12)/134/158/211(3)	30	17,390	15,744	19,209	
	19,640	216	91	14/20	68(3)/140(3)/146/148/166(6)	50	19,237	17,924	20,646	
	16,720	209	80	1/20	11	84	23,290	19,644	27,614	
	12,555	279	45	1/20	21	99	30,092	21,000	43,120	2.329
	5,940	297	20	0/20	-					
Guinea Pig	16,720	209	80	16/20	11(6)/17/35(7)/42/64/96	1	420	154	1,142	
	12,555	279	45	19/20	19(14)/26(2)/528(2)/552	16	1,658	971	2,833	
	5,940	297	20	11/20	16(8)/21(2)/40	30	2,692	1,805	4,017	
	2,960	212	14	8/20	14/16/38(5)/70	50	4,623	3,391	6,303	
	1,100	220	5	1/20	230	84	12,885	8,252	20,119	
						99	50,840	20,849	123,970	.3878

*Number in parenthesis indicates number of mortalities at the given times; otherwise, a single mortality occurred at the given time.

TABLE 8 - continued

Species	Statistical Analysis				
	P	ED(P)	Lower	Upper	Standard Error
All Rodents Combined (Rat & Guinea Pig)	1	563	42	7,404	
	16	3,079	931	10,175	
	30	5,609	2,733	11,512	
	50	10,951	8,397	14,282	
	84	38,947	15,269	99,344	
	99	213,003	21,093	2,150,884	.24153
Non Rodents Combined (Monkey, Dog, Goat, Swine)	1	665	32	13,365	
	16	4,144	1,077	15,949	
	30	7,948	3,631	17,397	
	50	16,435	11,730	23,026	
	84	65,169	18,373	231,153	
	99	412,310	21,974	7,736,196	.400329
All Species Combined	1	1,093	298	4,005	
	16	4,706	7,595	8,533	
	30	7,877	5,502	11,278	
	50	13,994	11,841	16,538	
	84	41,611	24,686	70,140	
	99	179,057	52,729	608,038	.230925

TABLE 9

DM INHALATION TOXICITY (M6A1 System)

(30-day observation period)

Species	Ct	Exposure Concentration	Exposure Time	Mortality	Time to Death (Days)	P	ED(P)	STATISTICAL ANALYSIS Lower Limit	Upper Limit	Standard Error
	(mg min/cu m)	(mg/cu m)	(min)							
Monkey	36,500	2,808	13	4/6	0.7(3)/0.8	1	4,324	441	42,314	
	34,900	2,685	13	6/6	0.75(4)/0.83/8.0	16	10,263	3,520	29,919	
	24,200	2,689	9	3/6	0.92/0.96(2)	30	13,923	7,169	27,041	
	17,600	2,514	7	4/6	1.0 (4)	50	19,569	14,193	26,980	
	14,400	1,800	8	3/6	1.8(3)	84	37,302	15,593	89,236	
	13,900	1,986	7	0/6	-	99	88,538	11,119	-	1.3657
Dog	43,700	2,913	15	5/5	0.2/0.9(3)/2.0	1	13,351	6,417	27,776	
	36,900	2,460	15	5/6	1.0(5)	16	20,482	13,906	30,167	
	29,500	2,269	13	2/6	1.0/3.8	30	23,821	17,878	31,739	
	17,600	2,514	7	1/6	1.7	50	28,193	22,573	35,212	
	14,300	1,586	9	0/6	-	84	38,802	27,857	54,049	
	6,200	886	7	0/6	-	99	59,529	30,599	115,812	2.1225
Goat	36,500	2,808	13	5/6	0.7(2)/0.8/2.0/3.0	1	368	.06310	x	
	34,900	2,685	13	6/6	0.75(5)/5.75	16	2,156	16.019	x	
	25,600	2,327	11	4/6	0.13/0.17(2)/2.1	30	4,025	111.63	x	
	14,400	1,800	8	4/6	1.8(2)/12.0/15.0	50	8,076	945.05	69,016	
	12,200	2,033	6	4/6	1.8(3)/12.0	84	30,228	10,062.5	90,804	
						99	x	1,663.8	x	1.3186
Swine	62,700	2,508	25	5/6	0.7(2)/0.9/1.7/7.0	1	2,746	.000937	8,047,813,100	
	45,700	2,688	17	4/6	0.7 (4)	16	12,151	35.105	4,206,301	
	39,000	2,435	16	1/6	2.0	30	20,540	1,405.204	200,255	
	14,900	2,129	7	3/6	1.0(2)/1.8	50	36,011	12,201.701	111,530	
	13,900	1,986	7	0/6	-	84	111,116	49.005	255,955,870	
						99	495,520	.0254	9,640,477,700,000	.94263
Rabbit	45,700	2,688	17	4/6	0.7(4)	1	2,292	.00116	4,522,860,000	
	39,000	2,600	15	5/6	0.13/1.0(4)	16	11,974	68.4338	2,095,405	
	39,000	2,435	16	4/6	2.0/2.7/6.9(2)	30	21,464	3,443.18	133,812	
	34,900	2,685	13	1/6	0.7	50	41,159	7,645.44	221,577	
	29,500	2,269	13	0/6	-	84	141,468	23.5162	851,040,070	
	18,600	2,657	7	4/6	18.0(2)/19.0(2)	99	739,116	.0109	49,695,989,000,000	.945197
	6,200	886	7	0/6	-					
Rat	88,000	2,588	34	14/20	0.04 (6)/0.08(4)/1.0(3)/2.0	1	16,409	13,496	19,951	
	80,000	2,666	30	15/20	0.04(4)/0.08(5)/1.0(5)/2.0	16	36,674	34,151	39,382	
	69,500	2,574	27	15/20	0.17(5)/1.0(9)/2.0	30	38,707	47,006	50,470	
	55,800	2,066	27	2/20	0.08/2.0	50	66,856	64,033	69,804	
	42,100	2,216	19	1/20	4.0	84	121,852	106,944	x	
	36,500	2,808	12	0/20	-	99	x	x	x	.6414
	34,900	2,685	13	5/20	10.8(5)					
	17,600	2,514	7	1/20	3.0					
	14,300	1,586	9	1/20	11.2					
Guinea Pig	17,600	2,514	7	18/20	0.13(6)/1.0(12)	1	2,542	1,705	3,789	
	14,400	1,800	8	19/20	0.08(4)/1.8(15)	16	6,353	5,388	7,492	
	14,300	1,586	9	5/20	0.8(4)/11.0	30	8,778	8,066	9,553	
	13,900	1,986	7	4/20	0.9(2)/4.0(2)	50	12,591	12,155	13,042	
	6,200	886	7	7/20	0.03(3)/1.0(2)/30(2)	84	24,946	20,552	30,278	
	5,540	1,385	4	0/20	-	99	62,350	40,619	95,704	.6952

*Number in parenthesis indicates number of animal mortalities at time indicated; otherwise, only one animal died at the given time.

DM INHALATION TOXICITY (No. 113 Federal Spedeheat Grenade)
30-Day Observation

TABLE 10

Species	Ct	Conc	Expo Time	Date of Expo	Mortality	Time to Death	Average Time of Death	Statistical Analysis P	ED(P)	Lower	Upper	Slope
	mg min/cu m	mg/cu m	min	1965		hours	hrs					
Rat	97800	3622	27	8/7	39/40	38(16)*,1(32)	16.4	1	11528	3768	35578	3.75
	77500	3875	20	8/7	35/40	33(17), 2(33)	17.9	16	26202	15778	43514	
	51600	3686	14	8/2	10/20	7(17), 696, 696, 696	-	30	34958	25935	47120	
	50550	3611	14	8/5	2/20	17,17	-	50	48217	42489	54718	
	42160	4216	10	7/29	1/20	19	-	84	88730	56188	140117	
	29000	3222	9	7/24	12/20	12(24)	-	99	200801	68819	585899	
	26270	3753	7	7/27	0/20		-	-	-	-	-	
	14600	2433	6	7/25	3/20	18,18,42	26.0	-	-	-	-	
	14240	3560	4	7/24	0/20	-	-	-	-	-	-	
Guinea Pig	77500	3875	20	8/7	39/40	19(1), 20(17)	9.2	1	9361	4325	20261	4.61
	51600	3686	14	8/2	17/20	0.5, 16(17)	16.03	16	18195	12624	26225	
	50550	3611	14	8/5	20/20	9(1.5), 11(17)	10.03	30	23005	18282	28950	
	42160	4216	10	7/29	15/20	2(2), 13(18)	15.9	50	29888	26615	33564	
	29000	3222	9	7/24	17/20	5(2), 4(4), 4(24), 597	8.9	84	49096	36623	65816	
	26270	3753	7	7/27	0/20	-	-	99	95432	47572	191439	
	25725	3675	7	8/4	0/20	-	-	-	-	-	-	
	14600	2433	6	7/25	1/20	18	-	-	-	-	-	
	14240	3560	4	7/24	6/20	18,42,402,402,448,449	293.5	-	-	-	-	
	8500	2125	4	8/5	0/20		-	-	-	-	-	
Rabbit	97800	3622	27	8/7	12/12	12(16)	-	1	16894	8279	34475	5.24
	77500	3875	20	8/7	12/12	12(17)	-	16	30333	21509	42777	
	60700	4669	13	8/4	2/6	18,18	-	30	37294	29534	47092	
	51600	3686	14	8/2	2/6	17,41	29.0	50	46959	39615	55665	
	42160	4216	10	7/29	2/6	18,96	57.0	84	72698	51964	101704	
	34600	4325	8	8/4	1/6	216	-	99	130527	64541	263975	
	29600	3222	9	7/24	4/6	2,2,24,24	13.0	-	-	-	-	
	26270	3753	7	7/27	0/6	-	-	-	-	-	-	
	25725	3675	7	8/4	0/6	-	-	-	-	-	-	
	14600	2433	6	7/25	0/6	-	-	-	-	-	-	
	14240	3560	4	7/24	0/6	-	-	-	-	-	-	
Dog	51600	3686	14	8/2	6/6	0,25,17,17,17,17,41	18.2	1	9699	2881	32659	4.98
	42160	4216	10	7/29	5/6	18,18,18,96,163	62.2	16	17952	9763	33009	
	29000	3222	9	7/24	2/6	48,70	59.0	30	23309	14686	33889	
	26270	3753	7	7/27	2/6	48,72	-	50	28428	21623	37376	
	14240	3560	4	7/24	1/6	304	-	84	45019	27875	72708	
	-	-	-	-	-	-	-	99	83322	28597	242771	
Monkey	29000	3222	9	7/24	6/6	3,3,5,5,24,28	11.3	1	8131	1097	60252	5.19
	26270	3753	7	7/27	1/6	17	-	16	14678	6838	31509	
	18200	3033	6	7/29	3/6	17,17,332	122	30	18080	12460	26235	
	14600	2433	6	7/25	1/6	42	-	50	22814	16297	31936	
	10400	2600	4	7/25	0/6	-	-	84	35459	10730	117182	
	-	-	-	-	-	-	-	99	64007	5539	739593	

Table 10 - continued

DM INHALATION TOXICITY (No. 113 Federal Spedeheat Grenade)
30-Day Observation

Species	Ct	Conc	Expo Time	Date of Expo	Mor-tality	Time to Death	Average Time to Death	Statistical Analysis				
								P	ED(P)	Lower	Upper	Slope
	mg min/cu m	mg/cu m	min	1965		Hours	hrs					
Swine	60000	5000	12	7/28	6/6	6(22)	-	1	20874	7405	58837	9.88
	43600	4360	10	8/3	4/6	5,5,22,22	13.5	16	28467	16713	48487	
	36135	4015	9	7/24	4/6	24,24,24,672	-	30	31761	22016	45821	
	22400	3200	7	7/28	0/6	-	-	50	35888	28854	44637	
	13140	3285	4	7/24	0/6	-	-	84	45245	32265	63446	
	-	-	-	-	-	-	-	99	61704	27086	140564	
Goat	97800	3622	27	8/7	6/6	0.5,0.5,0.5,0.5,16,16	5.7	1	1072	69	16671	2.23
	77500	3875	20	8/7	6/6	5(16), 138	36.3	16	4216	867	20497	
	60000	5000	12	7/28	5/6	22,240,240,456,648	167.3	30	6837	2084	22433	
	50550	3611	14	8/5	6/6	17,17,96,144,164,264	87.6	50	11723	5335	25763	
	36135	4015	9	7/24	5/6	68,68,600,624,624	-	84	32595	18155	58520	
	22400	3200	7	7/28	4/6	18,316,456,720	-	99	128200	26528	619545	
	13140	3285	4	7/24	4/6	18,260,472,552	283.3	-	-	-	-	
	8500	2125	4	8/5	2/6	600,672	-	-	-	-	-	
Rat &	-	-	-	-	-	-	-	1	8665	4030	18628	-
Guinea	-	-	-	-	-	-	-	16	20192	14243	28627	
Pig	-	-	-	-	-	-	-	30	27220	22095	33532	
	-	-	-	-	-	-	-	50	37980	34593	41699	
	-	-	-	-	-	-	-	84	-	-	-	
	-	-	-	-	-	-	-	99	166483	80755	343220	
Nonrodents	-	-	-	-	-	-	-	1	4988	2172	11453	2.98
(includes	-	-	-	-	-	-	-	16	13948	9411	20673	
rabbits)	-	-	-	-	-	-	-	30	20053	15576	25816	
	-	-	-	-	-	-	-	50	30063	25848	34965	
	-	-	-	-	-	-	-	84	64794	45804	91656	
	-	-	-	-	-	-	-	99	181199	82966	395738	
All	-	-	-	-	-	-	-	1	5823	111	306223	3.00
Species	-	-	-	-	-	-	-	16	16174	2792	93705	
	-	-	-	-	-	-	-	30	23197	8711	61770	
	-	-	-	-	-	-	-	50	34683	30245	39773	
	-	-	-	-	-	-	-	84	74374	15886	348206	
	-	-	-	-	-	-	-	99	206579	4862	8776949	

*Number in parenthesis indicates number of animal mortalities at time indicated: otherwise, only one animal died at the given time.

TABLE 11
INHALATION TOXICITY DATA FOR PURE DM
AND BLISS STATISTICAL ANALYSIS OF THE DATA FOR EACH EXPERIMENT IN EACH SPECIES OF ANIMALS
(1918-1964, Inclusive)

Species	Source	Date	Ct	Conc	Expo Time	Obs Period	Mortality	Time to Death	P	ED(P)	Upper	Lower	Slope
Rat	Ballard	Jun-Sep 57	540	181	30	2 wk	2/6	Not recorded	1	3901	3159	4817	13.2
			13200	440	30		6/6		16	4921	3885	6234	
			13250	442	30		6/6		30	5342	4137	6898	
			15660	522	30		6/6		50	5854	4582	7479	
			15950	532	30		6/6		84	6963	6550	7401	
									99	8783	5841	13209	
	Hickman		2004	167	12	2 wk	0/10	Not recorded	1	2051	815	5163	4.0
			4136	188	22		1/10		16	4346	2908	6493	
			5460	182	30		4/10		30	5665	4377	7331	
			7363	199	37		4/10		50	7614	6051	9579	
			8250	165	50		6/10		84	13340	7765	22917	
			10800	108	100		7/10		99	28263	9627	83006	
	Ballard	Sep 63	569	Not	Not re-	2 wk	0/10	Not recorded	1	133	7	2525	2.4
	Hickman		1122	recorded	corded		8/10		16	487	103	2294	
	DM-1		2385				8/10		30	770	263	2253	
			4069				6/10		50	1285	710	2326	
			5823				10/10		84	3394	1610	7152	
			7423				10/10		99	12454	1543	100498	
	Hickman		300	Not	Not re-	2 wk	0/10	Not recorded	1	290	6	13173	2.4
	DM-1		1030	recorded	corded		2/10		16	1036	607	1768	
			2255				4/10						
									50	2677	719	9971	
									84	6921	175	273355	
									99	24689	29	20984666	
	Hickman		2075	208	10	2 wk	0/10	Not recorded			Not applicable		
	C-8		4155	208	20		0/10						
			6000	240	25		0/10						
			8096	245	33		0/10						
			10124	260	39		0/10						
			12242	395	31		0/10						
	Hickman		2832	354	8	2 wk	0/10	Not recorded	1	23704	15076	37270	14.5
	A-19		7292	561	13		0/10		16	28271	27531	31120	
			11720	617	19		0/10		30	31533	28316	35116	
			21410	824	26		0/10		50	34264	29726	39495	
			27810	927	30		1/10		84	40109	25711	62570	
			32918	968	34		4/10		99	49528	21764	112708	
	Hickman		612	Not	Not re-	2 wk	0/10	Not recorded	1	232	4	14068	2.3
	DM-1		792	recorded	corded		2/10		16	891	235	3378	
			1808				0/18		30	1432	891	2301	
			2480				1/10		50	2431	987	5989	
			3560				10/10		84	6631	351	125401	
									99	25424	82	7973664	
	Ballard	1957	2149	72	30	2 wk	5/6	Not recorded	1	61	0.0005	7721281	1.7
			4388	293	15		3/6		16	376	0.342	412191	
			6600	220	30		6/6		30	712	3	145528	
			6960	232	30		4/6		50	1454	47	44912	
			10080	336	30		6/6		84	5627	2667	11869	
			18700	623	30		6/6		99	34465	318	3737671	
			19200	640	30		6/6						
Mouse	Hickman	11 Feb 64	2400	120	20	2 wk	0/10		1	1861	1193	2902	5.0
			4136	188	22		1/10	15-20 min	16	3431	2762	4262	
			5460	182	30		4/10	15-30 min	30	4257	3639	4980	
			7363	199	37		4/10	10-15 min (3), 45	50	5417	4732	6201	
			8250	165	50		6/10	15-30 min(3),ON(3)	84	8552	6683	10943	
			10800	108	100		7/10	<30 min(7)	99	15768	9766	25456	
	Ballard	June 57	315	10.5	30	2 wk	0/6	Not recorded	1	6	0	x	0.5
			2150	143	15		2/6		16	1615	0.001	246890910	
			15780	526	30		3/6		30	11814	663	210551	
			16650	1110	15		1/6		50	108715	197	59868752	
			53150	1772	30		2/6		84	7316343	0	x	
			55320	3688	15		0/6		99	205256510	0	x	
			60500	2420	25		4/6						
			70000	2333	30		5/6						
			84990	2833	30		2/6						

Table 11 -continued

Guinea Pig	Ballard	Jul-Sep 57	3800	127	30	2 wk	0/4	Not recorded	1	1397	263	7412	2.4
			4550	152	30		0/4		16	4996	2125	11746	
			5900	197	30		2/4		30	7933	4297	14272	
			11600	387	30		2/4		50	12936	8616	19421	
			13000	433	30		3/4		84	33498	17429	64380	
			16400	547	30		3/4		99	119779	28381	505509	
			18200	607	30		2/4						
			19400	647	30		2/4						
			25300	843	30		1/4						
			27400	913	30		3/4						
			29640	988	30		4/4						
			37800	1260	30		4/4						
			85200	2840	30		4/4						
	Hickman	Sep 63	1350	135	10	2 wk	2/10	2-3 da	1	450	52	3936	2.2
			2475	124	20		2/10		16	1766	766	4072	
			3225	161	20		2/10		30	2861	1724	4748	
			8875	178	50		8/10		50	4900	2684	8946	
									84	13596	2988	61853	
									99	53322	2921	973507	
	Ballard	Sep 63	569	Not	Not re-	2 wk	0/10	Not recorded	1	160	0.016	1649895	1.1
	Hickman		1122	recorded	corded		0/10		16	2529	1845	3467	
	DM-1		2385				4/10		30	6701	1012	44363	
			4069				3/10		50	19865	99	3991104	
			5823				2/10		84	156018	1	1701458600	
			7423				2/10		99	2465079	0.005	x	
	Ballard	Sep 63	1041	Not	Not re-	2 wk	5/10	Not recorded	1	1.2	0.061	1526	9.79
	Hickman		1178	recorded	corded		5/10		16	60	3	1126	
	DM-1		2282				6/10		30	238	74	770	
									50	1102	277	4380	
									84	20064	1900	211849	
									99	977989	1325	7217768450	
	Ballard	Sep 63	2075	208	10	2 wk	2/10	24 hr	1	53	0.07	42624	0.96
	Hickman		4155	208	20		4/10		16	1300	162	10434	
	C-8		6000	240	25		2/10		30	4032	2444	6650	
			8029	244	33		5/10		50	14249	6529	31098	
			10124	260	37		4/10		84	156183	1879	13002838	
			12242	395	31		5/10		99	3856174	491	4027738800	
Dog	Ransom	1918	3300	110	30		0/2		1	879	1.6	x	1.9
	Bogart		4200	140	30		0/2		16	4237	219	82048	
			9000	300	30		2/2	48,72 hr	30	7382	1197	45541	
			12000	400	30	14 da	1/2	12 da	50	13718	6320	29776	
			18000	600	30	12,14 da	2/4	50 hr, 14 da	84	44393	4447	x	
			21000	700	30	12 da	1/2	10 da	99		764	x	
			24000	800	30	12,15 da	2/4	18, 48 hr					
			27000	900	30		2/2	18,18 hr					
			27600	920	30		2/2	12,48 hr					
			30300	1010	30	12 da	1/2	4 da					
	Weimer	16 Sep 63	9955	Not	Not re-	Not re-	0/2	Not Recorded	1	5160	2916	9132	3.8
			14951	recorded	corded	corded	1/2		16	11637	4121	32864	
			24956				1/2		30	15506	5139	46791	
									50	21358	7272	62727	
									84	39200	20531	74846	
									99	88400	22532	346821	
	Hazleton	1 Sep 63	1610	107	15	30 da	0/2	Not recorded	1	15277	No answers		57.0
			14400	480	30		0/2		16	16121			
			19500	433	45		2/2	2, 3 da	30	16430			
			35000	583	60		2/2	1, 3 da	50	16782			
			64200	433	125		2/2	1, 1 da	84	17469			
									99	18434			
	Weimer	May 64	5100	Not	Not re-	2 wk	0/8	Not recorded	1	5285	1274	21920	4.1
	Hickman		8517	recorded	corded		1/8		16	11266	6292	20269	
			16680				2/8		30	14716	10034	21584	
			25040				6/8		50	19827	13157	29880	
									84	34895	13427	90687	
									99	74393	11928	463958	
Monkey (Rhesus)	Hazleton	1 Sep 63	1610	107	15	30 da	0/2	Not recorded	1		No limits		31.5
			14400	480	30		0/2		16	24266			
			19500	483	45		0/2		30	25115			
			35000	583	60		2/2	11, 12 da	50	26098			
			64200	433	125		2/2	1, 1 da	84	28067			
									99	30939			
Monkey (Squirrel)	Weimer	May 64	5880	147	40	Not	0/6	Not recorded	1	2919	130	65560	4.3
	Hickman		9464	182	52	recorded	2/6		16	5930	1444	24353	
			10725	215	50		6/6		30	7616	3323	17457	
			12710	155	82		4/6		50	10069	7399	13702	
			23760	167	142		5/6		84	17091	5070	57612	
									99	34726	1891	x	

TABLE 12

INHALATION TOXICITIES OF 10 DAILY EXPOSURES TO DM (No. 113 Fed. Labs. Grenade)

Day	Daily Ct	Cumulative Ct	Deaths G.P.	Deaths Monkey	Deaths Monkey	Daily Ct	Cumulative Ct	Deaths G.P.	Deaths Dog	Deaths Monkey
	mg min/cu m	mg min/cu m				mg min/cu m	mg min/cu m			
1	9,740	-	0/20	0/8	0/8	16,620	-	1/20	0/8	0/8
2	12,020	21,760	-	-	-	16,020	32,640	-	1/8	1/8
3	11,060	32,820	-	-	-	17,560	50,200	-	-	2/8
4	11,000	43,820	-	-	-	15,920	66,120	-	-	-
5	12,920	56,740	-	-	-	16,920	83,040	-	2/8	-
6	11,620	68,360	-	-	-	17,360	100,400	-	-	3/8
7	11,750	80,110	-	-	-	14,540	114,940	-	-	-
8	9,940	90,050	-	-	-	19,020	133,960	3/20	-	-
9	13,720	103,770	1/20	-	-	21,660	155,620	4/20	-	-
10	12,320	116,090	1/20	0/8	0/8	17,400	173,020	4/20	2/8	3/8
11			2/20	-	2/8			12/20	-	4/8
12			2/17	-	3/8			18/20	-	6/8
13			-	-	4/8			-	-	-
16			-	1/8	-			-	-	-
17			-	-	-			-	-	8/8
20			3/17	-	-			-	-	-
24			-	-	5/8			-	-	-
30			3/17	1/8	5/8			18/20	2/8	8/8

ACUTE LETHAL CT's FOR DM (No. 113 Spedeheat Grenade)

	Guinea Pig		Dog		Monkey
P	mg min/cu m	P	mg min/cu m	P	mg min/cu m
1	9,361	1	9,699	1	8,131
16	18,195	16	17,952	16	14,678
30	23,005	30	23,309	30	18,080
50	29,888	50	28,428	50	22,814
84	45,096	84	45,019	84	35,459
99	95,432	99	83,322	99	64,007

CN Acute Inhalation Toxicity - continued

Species	Ct mg min/cu m	Concentration mg/cu m	Exposure Time min	Mortality	Times to Death hrs	Statistical Analysis P	ED(P)	Lower Limit	Upper Limit	Probit Y(-)	Log x (+)	Standard Error
												–
Rat	55,650	3,975	14	20/20	4 (6), 6 (3), 18 (10), 20(1)	1	8,332.9	5,135.8	13,520.3	17.7	5.20	.93
						16	15,024.3	11,416.0	19,772.9			
	36,100	4,011	9	18/20	14(4), 24 (5),38(6) 52 (3)	30	18,499.3	14,998.2	22,817.6			
						50	23,332.2	19,974.5	27,254.2			
	32,886	2,892	10	16/20	24 (11),48(4), 62(1)	84	36,234.0	30,437.3	43,134.6			
	25,086	2,826	8	7/20	16 (2), 48 (5)	99	65,330.0	45,625.0	93,545.4			
	12,550	2,092	6	3/20	45(3)							
	2,700	675	4	0/20	-							
Guinea Pig	55,650	3,975	14	20/20	2 (5), 4 (3), 6 (3), 18 (8), 120, (1)	1	972.2	110.9	8,515.8	3.12	1.93	.34
						16	4,727.2	1,723.2	12,967.8			
	36,100	4,011	9	11/20	14 (5), 24 (6)	30	8,261.3	4,431.2	15,401.9			
	25,086	2,826	8	12/20	16 (5), 48(6), 593(1)	50	15,399.0	11,243.4	21,090.5			
	12,550	2,092	6	8/20	21 (6), 48 (2)	84	50,162.7	21,100.2	119,254.9			
	8,470	1,694	5	11/20	24 (3), 48 (4), 96 (2) 120 (1), 144 (1)	99	243,907.2	32,346.9	1,839,150.2			
	2,700	675	4	0/20	–							
All Rodents	–	–	–	–	–	1	2,160.5	677.6	6,888.5	5.79	2.54	.31
	–	–	–	–	–	16	7,232.6	4,081.7	12,815.6			
	–	–	–	–	–	30	11,079.4	7,611.0	16,128.3			
	–	–	–	–	–	50	17,829.4	14,612.9	21,753.9			
	–	–	–	–	–	84	43,952.1	29,633.9	65,188.5			
						99	147,137.3	55,733.5	388,444.8			
All Non-Rodents	–	–	–	–	–	1	1,179.9	454.4	3,063.0	4.70	2.40	.32
	–	–	–		–	16	4,231.9	2,666.6	6,715.8			
	–	–	–	–	–	30	6,642.3	4,875.8	9,048.9			
	–	–	–	–	–	50	10,983.0	8,920.3	13,522.7			
	–	–	–	–	–	84	28,504.4	18,811.1	43,192.7			
	–	–	–	–	–	99	102,230.8	41,445.3	252,166.6			
All Species Combined	–	–	–	–	–	1	1,302.3	603.2	2,811.5	4.31	2.24	.20
	–	–	–	–	–	16	5,114.3	3,517.8	7,435.5			
	–	–	–	–	–	30	8,288.7	6,474.3	10,611.6			
	–	–	–	–	–	50	14,203.9	12,223.9	16,504.6			
	–	–	–	–	–	84	39,448.0	29,065.4	53,539.4			
	–	–	–	–	–	99	154,918.4	77,323.1	310,382.7			

*Number in parenthesis indicates number of animals that died at the time indicated.