

UNCLASSIFIED

AD NUMBER
ADB058048
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; MAY 1981. Other requests shall be referred to Commander/Director, Chemical Systems Laboratory, Attn: DRDAR-CLJ-R, Aberdeen Proving Ground, MD 21010.
AUTHORITY
CRDEC ltr, 29 Mar 1990

THIS PAGE IS UNCLASSIFIED

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

**DISPOSITION INSTRUCTIONS**

Destroy this report when it is no longer needed.  
Do not return it to the originator.



PREFACE

The work described in this report was authorized under Project 1M162622A554, Chemical Munitions and Chemical Combat Support; Technical Area 4-5, Smoke Toxicology. The work was started in July 1978 and completed in May 1980. The experimental data are contained in notebook 9839.

In conducting the research described in this report, the investigators adhered to the "Guide for the Care and Use of Laboratory Animals" as promulgated by the Committee on Revision of the Guide for Laboratory Animals Facilities and Care of the Institute of Laboratory Animal Resources, National Research Council.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

Reproduction of this document in whole or in part is prohibited except with permission of the Commander/Director, Chemical Systems Laboratory, ATTN: DRDAR-CLJ-R, Aberdeen Proving Ground, Maryland 21010. However, the Defense Technical Information Center is authorized to reproduce the document for United States Government purposes.

This report has not been approved for release to the public.

Acknowledgment

The authors wish to acknowledge the following:

Clarence E. Hopkins for the performance of gross necropsies and body-organ weight data.

John F. Miller and Franklin Tittle for preparation of blood samples for chemical analysis and statistical analyses of the results.

Malcom N. Allison, CPT, V.C., for histopathology. These data are included verbatim as appendixes.

William Lane for his technical assistance.

**DTIC**  
**ELECTE**  
**S** JUL 13 1981 **D**  
**B** \_\_\_\_\_

Accession For	
NTIS GRA&I	<input type="checkbox"/>
DTIC TAB	<input checked="" type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/ _____	
Availability Codes	
Dist	Avail and/or Special
<b>B</b>	

## CONTENTS

	Page
1 INTRODUCTION .....	7
2 EXPERIMENTAL PROCEDURES .....	7
2.1 Chamber Operation and Sample Collection .....	7
2.2 Animals Used .....	8
2.3 Animal Exposures and Observations .....	8
2.4 Blood Studies .....	8
2.5 Pathology .....	8
2.6 Physiological and Behavioral Studies .....	9
3 RESULTS .....	9
3.1 Exposure Conditions .....	9
3.2 Toxic Signs .....	9
3.3 Body-Organ Weights .....	9
3.4 Hematology and Blood Chemistry .....	9
3.5 Pathology .....	10
3.6 Reproduction Studies .....	10
3.7 Physiological Studies .....	11
3.8 Behavioral Studies .....	13
4 DISCUSSION .....	13
5 CONCLUSIONS .....	14
LITERATURE CITED .....	15
APPENDIXES .....	17
A. Chemical Analysis of White Phosphorus Smoke .....	17
B. Details of Toxicological Evaluation .....	19
C. Pathology Report - Spontaneous Deaths .....	39
D. Pathology Report - 6-Week Exposure .....	55
E. Pathology Report - 13-Week Exposure .....	79
F. Pathology Report - 13-Week Exposure and 4-Week Recovery Period .....	103
DISTRIBUTION LIST .....	127

## THE SUBCHRONIC EFFECTS OF REPEATED EXPOSURE TO WHITE PHOSPHORUS/FELT SCREENING SMOKES IN RATS

### 1. INTRODUCTION

Toxicity studies were conducted to determine the subchronic effects of repeated exposure to three concentration levels of a white phosphorus screening smoke. This smoke, one of the candidate screening smokes, was generated by burning pieces of white phosphorus-impregnated felt.

The following studies were performed to obtain a subchronic toxicity profile on rats: inhalation toxicity of multiple exposures, including pathology, hematology, and blood chemistry, and effects of exposures on reproduction, behavior, and physiology.

### 2. EXPERIMENTAL PROCEDURES

#### 2.1 Chamber operation and sample collection.

Animals for the inhalation studies were placed in compartmented stainless-steel wire-mesh cages. The cages were put on racks in a 20-cubic-meter exposure chamber.

Military grade white phosphorus, which had been forced under pressure into thick pieces of wool felt, was cut into cubes having specific weights. For each exposure, one of these cubes on an aluminum foil pan of a known weight was placed on an electric hotplate within the chamber. The hotplate was a fast-heating unit capable of temperatures in excess of 700°F.

The chamber door was closed and sealed, and the chamber exhaust system was shut down. The hotplate was plugged in and the white phosphorus/felt ignited, usually in less than 2 minutes, producing a dense white smoke. This smoke is made up of a number of oxides of phosphorus:  $P_4O \cdot P_2O \cdot P_2O_3$  (or  $P_4O_6$ ),  $PO_2$  (or  $P_2O_4$ ),  $P_2O_5$  (or  $P_4O_{10}$ ), and  $P_2O_6$ ; but only three of these species -  $P_2O_3$ ,  $PO_2$ , and  $P_2O_5$  - are well established.<sup>1</sup> All three of these oxides are deliquescent and they could, therefore, contribute various aqueous droplets to the smoke. The reaction of  $P_2O_5$  with atmospheric moisture has already been described; the corresponding reaction for  $P_2O_3$  produces o-phosphorus acid. The tetraoxide,  $P_2O_4$ , reacts with water to produce equimolar solutions of o-phosphorous and o-phosphoric acid.<sup>1</sup> The white phosphorus/felt burning time ranged from less than 1 minute for some of the small cubes to over 9 minutes for one of the large cubes. The smoke was contained within the chamber for 15 minutes before being removed by the exhaust system.

Smoke sampling started after 7 minutes of exposure. The samples were collected on Gelman Type-A glass fiber filter pads. Twelve liters of chamber air, at the rate of 3 liters per minute, were drawn through the filter pads contained in the air sampler probe. The filter pads were placed in Erlenmeyer flasks. Particulate material was extracted with distilled water, boiled for 10 minutes, and titrated for phosphoric acid content (see appendix A).

Air samples were also collected in a modified Rochester cascade impactor and analyzed for phosphoric acid content, and the mass median diameter of the airborne particles was derived.

## 2.2 Animals used.

Four groups of Sprague-Dawley rats were used, one for each dose level plus the controls. Thirty-six male and 36 female rats were used for the high- and intermediate-exposure levels with 18 rats of each sex acting as controls for each level. Only 18 males and a like number of females were exposed to the low-dose level. Nine animals of each sex acted as controls for this exposure.

Additional groups of rats were exposed and the rats were mated on different schedules to determine the effects of repeated exposures on mammalian germ cells and reproductive performance. Procedures used are discussed in a previous report.\*

## 2.3 Animal exposures and observations.

Animals were exposed for 15 minutes daily, 5 days a week for 13 weeks. The rats were observed for toxic signs before and after each exposure. At regular intervals during the 13-week exposure and 4-week postexposure periods, all animals were weighed.

After 6 weeks, one-third of the animals were withdrawn from exposure. Half of these animals were bled and submitted to pathology. The other half were examined to see if any physiological or behavioral changes occurred. When the 13 weeks of exposure ended, the remaining animals were separated into two groups. One group was divided as were the 6-week animals with half going to pathology and half for physiological and behavioral studies. The remaining animals were held for a 4-week postexposure period to observe any recovery that might occur. Then they were bled and submitted for pathological evaluation.

## 2.4 Blood studies.

Blood samples in rats were analyzed for triglycerides, cholesterol, glucose, urea nitrogen, creatinine, uric acid, sodium, potassium, chloride, carbon dioxide, alkaline phosphatase, albumin, globulin, calcium, phosphorus, serum glutamic pyruvic transaminase, serum glutamic oxalacetic transaminase, red blood cell count, white blood cell count, differential white blood cell count, hematocrit, and hemoglobin.

## 2.5 Pathology.

Gross and microscopic pathological examinations of the following body organs were performed for all animals submitted: heart, lung, liver, spleen, kidney, brain, eye, trachea, nasal turbinate, adrenal, stomach, urinary bladder, pancreas, thyroid, esophagus, duodenum, colon, lymph node, thymus, testis, epididymus, ovary, uterus, bone marrow, and skin. In addition to those animals sacrificed at 6, 13, and 17 weeks, animals that died during the experiments were submitted for necropsies. The number sacrificed at each time interval was adjusted according to the number of animals that died during that interval.

---

\*Starke, W. C., and Pellerin, R. J. Technical Memorandum. The Effects of CS-2 on Reproduction in Rats (in preparation). 1980.

2.6 Physiological and behavioral studies.

Animals were submitted for physiological and behavioral evaluations using the procedures described in a previous publication.<sup>2</sup>

3. RESULTS

3.1 Exposure conditions.

Target concentrations were 1000, 500, and 200 mg/m<sup>3</sup>. Target and actual concentrations are used interchangeably in the appendixes. Concentrations are also referred to as high, intermediate, and low, respectively. To obtain desired concentrations, 20-, 10-, or 3-gram cubes of the white phosphorus-impregnated felt were used. When ignited, a dense white smoke-like mist was produced. The droplets of this mist had a mass median diameter of 0.5 micron. A charred residue weighing approximately 27% of the original weight remained after burning.

Appendix B, table B-1, shows the mean exposure doses produced by each cube recorded.

3.2 Toxic signs.

Animals were not visible for observation until the smoke cloud was evacuated from the chamber. Visible toxic signs were not observed during the first 3 days of exposure to the high dose. One hour after the fourth exposure one female rat died. Two other rats wheezed for about 2 hours. Of the 72 rats starting this high-dose study, 23 died during the first 6 weeks of exposure. Four more died during the remaining 7 weeks. Transitory dyspnea and wheezing were observed in many rats, with recovery within 2 hours of each exposure. The cumulative exposures at which deaths occurred are shown in appendix B, table B-2.

Rats exposed to the intermediate and low doses showed no visible toxic signs. None of these animals died.

3.3 Body-organ weights.

There were no consistent changes in total body weights or in weights of the organs regardless of dose or time. Means and standard errors for body and organ weights of control and exposed rats are shown in tables B-3 and B-4, appendix B. Significant differences, where they did occur, are indicated.

3.4 Hematology and blood chemistry.

No agent-related changes were observed in the blood chemistry and hematology analyses. "T" test evaluations indicated there were no significant agent-related differences between control and exposed values. No sex-related changes were observed. Means and standard errors of all blood constituents analyzed are shown in tables B-5 through B-10, appendix B.

### 3.5 Pathology.

#### 3.5.1 Spontaneous deaths.

A high mortality rate (about 40%) occurred in the group of colony rats exposed to the 1161 mg/m<sup>3</sup> dose level. The deaths appear to be agent and dose related. None of the rats exposed to the intermediate- or low-dose levels died. A complete description of pathological findings is presented in appendix C.

#### 3.5.2 Six-week exposure.

Although laryngitis or tracheitis was not observed in any of the control animals, all laryngeal and tracheal specimens from rats exposed to the high-dose level displayed a moderate-to-severe laryngitis/tracheitis. Fifty percent of the rats receiving the intermediate-dose level displayed a minimal-to-mild tracheitis while one-third had a mild laryngitis. Only one rat receiving the low dose displayed tracheitis. Four of six high-dose rats had a minimal-to-severe interstitial pneumonia. Two of the 18 control rats displayed a minimal interstitial pneumonia. A complete description of these pathological findings is presented in appendix D.

#### 3.5.3 Thirteen-week exposure.

Although none of the control rats displayed laryngitis or tracheitis, all of the male rats receiving the high-dosage level of white phosphorus/felt exhibited a moderate laryngitis. Of the female rats receiving the same dosage level (1161 mg/m<sup>3</sup>) of white phosphorus/felt, one of two larynges examined displayed a moderate laryngitis; whereas two out of three tracheae displayed mild-to-moderate tracheitis. Three out of six female rats receiving the medium-dosage level of white phosphorus/ felt displayed a moderate tracheitis; whereas three out of five male rats receiving the same level exposure displayed slight-to-moderate tracheitis. None of the low-dosage-level animals displayed laryngitis or tracheitis. A complete description of these pathological findings is presented in appendix E.

#### 3.5.4 Thirteen-week exposure with four-week recovery period.

Significant findings were limited to the respiratory tracts of the rats exposed to the high- and intermediate-dose levels. Lesions were noted in the larynx or trachea of 15 of 16 high-dose rats and 20 of 24 intermediate-dose rats. Pulmonary lesions were noted in 11 of 16 high-dose and 6 of 24 intermediate-dose rats. None of the control or low-dose animals exhibited significant lesions. A complete description of these pathological findings is presented in appendix F.

### 3.6 Reproduction studies.

To assess the effects of white phosphorus/felt smoke on reproduction processes in rats, three studies were conducted: teratology, dominant lethal mutation, and reproduction in a single generation. Each of these studies was conducted at both the high- and intermediate-exposure levels and in the control (smoke-free) atmosphere.

At the high-dose level of each study, several of the animals died. Five of the 24 high-dose teratology females died before their scheduled necropsy date. Twelve of the 20 males for the single-generation study died prior to their time for mating. Nine of the 20 males for the dominant lethal mutation study died before they could be mated.

### 3.6.1 Teratology.

Pregnant females were exposed to test and control atmospheres from days 6 to 15 of gestation. There were no major abnormalities found among the control or test fetuses. The pregnancy rates for control, intermediate-dose and high-dose smoke were 100%, 100%, and 90%, respectively. Data on the number and condition of implants, the mean body weights of the fetuses, and the averaged data on implants appear in appendix B, table B-11. Statistical analysis of these data showed no differences between control and treatment groups.

### 3.6.2 Dominant lethal mutation.

In the dominant lethal mutation study, analysis by the chi-square method showed that, for the first mating, significantly more of the dams mated to intermediate-dose males had one or more resorptions as compared to the dams mated to control males, appendix B, table B-12. This difference was not observed at the high dose, indicating that the difference observed with the intermediate-dose group was probably not attributable to the effects of white phosphorus/felt smoke.

### 3.6.3 Single-generation reproduction.

The single-generation reproduction study results are more difficult to analyze. Although there were no significant differences in the body weights of the pups at birth, survivability of the exposed pups was significantly lower than that of the control pups, appendix B, table B-13. Exposures continued for the pups and dams through this 21-day period. Weight gain in the surviving exposed pups was less than that of the control pups, appendix B, table B-14. The difficulty arises from the inability to discern whether the deficiency in weight gain was (1) the result of the exposed dams not caring for their pups, (2) a decrease in mammary gland secretion, (3) the inability of the pups to nurse because of irritated and congested tracheas, or (4) exposure effects.

### 3.7 Physiological studies.

Physiological measurements were made on days 3 and 4 after the animals were removed from the exposure. The number of animals (sample size) used in the tests are shown in appendix B, tables B-15 and B-16.

An analysis of variance (ANOVA) was made on the data to determine the effect of dose (exposure level), sex difference, and the effect of dose within sexes. Following this, a T-test was performed to locate any significant differences.

The logic for determining a physiological effect from the white phosphorus/felt smoke required that the following conditions apply: (1) a significant difference at a  $P \leq 0.05$  level be evidenced by the analysis of variance and Student T test, (2) the differences must be dose related and directional so that significant differences occurring in a low-dose group that were not reinforced by similar effects in the high-dose groups would be considered a chance occurrence, and (3) the difference should be time related unless an adaptive response for increased tolerance has developed. With a bioaccumulated material, it would be expected that effects shown after a 6-week exposure would be repeated after a 13-week exposure. With white phosphorus smoke, it is interesting to note from pathology (page 10) that upper airway irritation, i.e., tracheitis and laryngitis,

decreased after a 6-weeks' exposure. Assuming that phosphorous pentoxide unites with water lining the respiratory tract to form a phosphoric acid, the response to this irritant may be decreasing with time of exposure and consequently the application of present statistical judgments takes the possibility of increased tolerance into effect.

The results are shown in appendix B, tables B-15 through B-17. At both 6- and 13-weeks' exposure, significant sex differences were shown which appear to be related to the greater size of the male rats. These included breathing volumes and the increased inhaled volume responses to 6% CO<sub>2</sub>. In addition, blood pressures from male rats were slightly higher than those of female rats. This has been observed in other tests.

Some differences appeared to be the effect of dose and these are indicated in tables B-15 and B-16. However, none of these effects satisfied the logic described above for determining a physiological effect. The same applies for the sex-related doses. It is noted that the sample size in the high-dose exposures was reduced because of deaths during the procedure. It is possible that, if the sample size were larger for high-dose groups, a statistical significance would have been noted. It appears that some effect was developing in the group toward a reduction in tidal volume and an increase in breathing frequency with dose in the 13-week exposed animals. There is also indication that there was less growth in the male rats of this group.

Table B-17 contains the qualitative or nonparametric observations made on rats in the exposure groups. Three of the 13-week high-exposure groups had loud bubbly rales 3 days after exposure which were absent on the fifth post-exposure day.

Although no statistical validation for a functional effect exists, the presence of rales and the tendency for a reduction in tidal volume and an increase in breathing frequency in the high-dose animals indicate that a careful examination of the lung pathology data and the pulmonary resistance data be made.

The evaluation of the pulmonary function as a result of exposure to white phosphorus/felt smoke was carried out on rats that had been exposed for a period of 13 weeks. The method for estimating the pulmonary resistance in these animals was based on a comparison of the plethysmographic pressure during a respiratory cycle and the peak respiratory flow. The rationale for using this method is based on the principle that the changes in pressure in a body plethysmograph during a respiratory cycle are proportional to the alveolar pressure during post cycle. (Pulmonary resistance is determined by the ratio of alveolar pressure to the flow rate during a respiratory cycle; therefore, an estimate of the resistance can be determined by substituting the plethysmographic pressure for the alveolar pressure.)

The results of the pulmonary tests in the unanesthetized rat following 13-weeks exposure to white phosphorus/felt smoke are presented in appendix B, table B-18. There were no significant differences from control values in the respiratory rate or peak inspiratory flow rates in either males or females exposed to smoke. There was no significant difference in the estimated pulmonary resistance of the female rats following exposure. The estimated pulmonary resistance of exposed male rats had a tendency to increase slightly over that of the controls. This increase was significantly different in the low-dose rats but not in the high-dose animals; however, the indication is that some pulmonary damage may be present in the male rats exposed to white phosphorus/felt smoke. No rats were tested at 6 weeks postexposure.

### 3.8 Behavioral studies.

The behavioral responses of rats exposed to white phosphorus smoke for 6 or 13 weeks was measured using spontaneous activity and passive avoidance tests. In all instances, values are compared statistically to a group of unexposed control rats of equal age and weight.

#### 3.8.1 Spontaneous activity.

The results of these tests are presented in appendix B, table B-19, which shows the gross and fine activity of the rats and the ratio between these two types of activity. Both male and female animals exposed for 6 weeks appeared to exhibit a difference in activity; however, the mean values presented were influenced by one or two animals from each group including controls. If the ratio is calculated from these means, the values become more uniform, indicating that spontaneous activity was not altered as a result of exposure.

#### 3.8.2 Passive avoidance.

Passive avoidance test results are presented in appendix B, table B-20. The exposed female rats, at 1161- and 589-mg/m<sup>3</sup> dose levels and 6-week/13-week exposure time periods, were no different from control animals. This indicated that the animals' ability to passively avoid shocks was not adversely affected by exposure to white phosphorus smoke.<sup>1</sup> Male rats exposed to the high dose received more shocks than the control rats but statistically the values were not significantly different. The number of passive avoidance responses were no different. One of the 13-week high-dose male rats received an unusually large number of shocks with no attempted avoidance, raising the mean value for this group of animals. This animal had either a higher pain threshold than the other animals or a delay in determining how to avoid the shock. The lower-dose male rats showed no differences from the control animals.

## 4. DISCUSSION

When white phosphorus burns, it forms a number of oxides of phosphorus which are rapidly converted by moisture to phosphorus and phosphonic acids.<sup>1,3</sup> Although at ordinary expected field concentrations (100-200 mg/m<sup>3</sup>), this may not be hazardous, some irritation to the eyes, nose, and throat may occur.<sup>4</sup> Cullumbine<sup>5</sup> exposed a total of 108 men to white phosphorus smoke at concentrations from 87 to 1770 mg/m<sup>3</sup>. Throat irritation was produced at all concentrations. From these data, it has been estimated that the minimum harassing concentration (requiring a respirator) is about 700 mg/m<sup>3</sup>. In the documentation for threshold limit values (TLV), it has been reported that concentrations of 100 mg/m<sup>3</sup> were unendurable except to hardened workers.<sup>6</sup> A TLV of 1 mg/m<sup>3</sup> was established as the level to which nearly all workers may be repeatedly exposed without adverse effect. A man exposed to 100 mg/m<sup>3</sup> would probably mask or remove himself from the smoke cloud.<sup>7</sup>

In the study just completed, the 1000 mg/m<sup>3</sup> dose, with 40% spontaneous deaths and injury to all other animals, was obviously a hazardous concentration. None of the animals exposed at the 500- or 200-mg/m<sup>3</sup> dose levels died. The intermediate dose did, however, produce tracheitis in 50% of the rats. Only one of the low-dose animals showed any signs of irritation.

5. CONCLUSIONS

It would appear that the chance of injury is high at 1161 mg/m<sup>3</sup> and low at 193 mg/m<sup>3</sup>. At 589 mg/m<sup>3</sup>, one-half of the rats showed some exposure effects.

The rats apparently developed a tolerance to repeated exposures, particularly at the lowest exposure level.

#### LITERATURE CITED

1. Milham, M. E., Anderson, D. H., Frickel, R. H., and Tarnove, T. L. ARCSL-TR 77067. New Findings on the Nature of WP/RP Smokes. July 1977.
2. Cummings, E. G., Armstrong, R., Farrand, R. L., and McNamara, B. P. ARCSL-TR-79015. Physiological and Behavioral Methodology for Evaluating Chemical Effects on Unanesthetized Rats. March 1979.
3. Van Wazer, J. R. Phosphorus and Its Compounds. Volume 1: Chemistry. pp. 267-279. Interscience Publishers, Inc., New York, New York. 1958.
4. Technical Manual TM 8-285. Treatment of Chemical Agent Casualties. p. 79. Department of the Army, the Navy, and the Air Force. January 1968.
5. Cullumbine, H. Porton Report 2604. The Burning Power and Harassing Effects of White Phosphorus. March 17, 1944.
6. Documentation of the Threshold Limit Values for Substances in Workroom Air. American Conference of Governmental Industrial Hygienists. 3rd edition. 1971.
7. Weimer, J. T., Affleck, G., Preston, J., Lucey, J., Manthei, J., and Lee, F. ARCSL-TR-77052. The Acute Effects of Single Exposures to United Kingdom Red Phosphorus Screening Smoke in Rats, Guinea Pigs, Rabbits, and Dogs. August 1977.

## APPENDIX A

### CHEMICAL ANALYSIS OF WHITE PHOSPHORUS SMOKE\*

Exposure chamber air samples received were diluted with distilled water, shaken, then boiled 10 minutes to convert the phosphorus acids to orthophosphoric acid, then cooled to room temperature. Sample volume was measured after boiling. Using a pH meter as an indicator, the acid content was determined by titration against 0.10043 N sodium hydroxide to a pH of 9.6. After measuring the amount of 0.10043 N sodium hydroxide required to adjust the sample pH to 9.6, the following formula was used to determine normality of the orthophosphoric acid:

$$1. N_{\text{sample}} \times V_{\text{sample}} = N_{\text{NaOH}} \times V_{\text{NaOH}}$$

N = Normality

V = Volume of sample in milliliters

The normality of the acid is multiplied by 32.66 (milligrams per milligram-equivalents of orthophosphoric acid).

$$2. \frac{\text{milligram equivalents}}{\text{milliliters}} \times \frac{32.66 \text{ milligrams}}{\text{milligram equivalents}} = \frac{\text{milligrams}}{\text{milliliters of orthophosphoric acid}}$$

(normality of sample)

$$3. \frac{\text{milligrams}}{\text{milliliters}} \times \text{milliliters} = \text{milligrams of orthophosphoric acid in sample}$$

\* B. P. Pearce. Porton Technical Paper 154. The Stability of Red Phosphorus Compositions. June 1974. UNCLASSIFIED Paper.

**APPENDIX B**  
**DETAILS OF TOXICOLOGICAL EVALUATION**

**Table B-1. Inhalation Exposure Doses Produced by Burning Cubes of White Phosphorus/Felt**

Cube weight	Average exposure concentration	Average daily 15-minute exposure Ct	Total cumulative exposure Ct
gm	mg/m <sup>3</sup>	mg min/m <sup>3</sup>	mg min/m <sup>3</sup>
20	1161	17,415	1,097,151 (63 days)
10	589	8,833	556,480 (63 days)
3	192.5	2,887	178,991 (62 days)

Table B-2. Spontaneous Deaths in Rats Exposed to the High-Dose Concentration of White Phosphorus Smoke

Exposure day	Deaths		Cumulative exposure Ct mg min/m <sup>3</sup>
	Male	Female	
4		1	54,225
5	1		69,225
9	1		143,975
10	1		158,820
11		2	176,340
12	1	3	194,790
13	1	1	210,960
14	2	1	225,120
16		1	251,925
23	2		376,260
24		1	397,650
25	1		420,330
26	1		441,300
27	1		460,545
29		1	499,560
34	1		588,045
47	1		813,021
54	1		936,820
57	1		995,426





Table B-5. Hematology in Rats Exposed for Six Weeks to White Phosphorus Smoke

Cumulative exposure Ct	Red blood cells			White blood cells			Hematocrit			Hemoglobin			Neutrophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
		$\times 10^6/mm^3$	$\times 10^6/mm^3$		per $mm^3$	per $mm^3$		%	mg/100 ml	mg/100 ml	%	%		%	%
mg min/m <sup>3</sup>															
499,560	6	6.32	0.77	6	8333.33	1129.40	6	35.70	4.46	6	13.53	1.59	-	-	-
Control	6	6.90	0.58	6	9650.00	1698.77	6	38.53	2.95	6	15.10	0.87	-	-	-
246,285	12	7.02	0.53	12	6633.33	1818.12	12	39.11	3.34	12	14.42	0.94	-	-	-
Control	6	6.90	0.34	6	5966.67	1188.37	6	38.10	2.19	6	14.18	0.84	-	-	-
84,019	12	6.50	0.54	12	8325.00	1799.13	12	35.68	3.08	12	13.51	0.94	-	-	-
Control	6	6.95	0.41	6	10233.33	1569.15	6	38.58	2.10	6	14.68	0.71	-	-	-

Cumulative exposure Ct	Band cells			Lymphocytes			Mono cytes			Eosinophils			Basophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
		%	%		%	%		%	%		%	%		%	%
mg min/m <sup>3</sup>															
499,560	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
246,285	-	-	-	12	91.50	5.06	1	1.00	0.00	6	2.17	1.67	-	-	-
Control	-	-	-	6	92.67	4.57	1	1.00	0.00	1	1.50	0.76	-	-	-
84,019	-	-	-	12	90.25	5.55	1	2.00	0.82	2	2.00	1.00	-	-	-
Control	1	1.00	0.00	6	88.00	4.93	3	2.00	0.82	2	2.00	1.00	-	-	-

+ Significantly lower than control based on statistical "t" test.  
 NOTE: Statistical evaluation of differential-white count components, monocytes, eosinophils, basophils and band cells may be meaningless since normal occurrences range from 1% to 10%.

Table B-6. Hematology in Rats Exposed for Thirteen Weeks to White Phosphorus Smoke

Cumulative exposure Ct mg min/m <sup>3</sup>	Red blood cells			White blood cells			Hematocrit			Hemoglobin			Neutrophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
		x 10 <sup>6</sup> /mm <sup>3</sup>	x 10 <sup>6</sup> /mm <sup>3</sup>		per mm <sup>3</sup>	per mm <sup>3</sup>		%	mg/100 ml	mg/100 ml		%		%	%
1,097,151	12	7.32 <sup>+</sup>	0.59	12	15,125.00	5301.47	12	40.12 <sup>+</sup>	3.40	2	15.43 <sup>+</sup>	1.28	10	31.10 <sup>++</sup>	12.04
Control	6	8.12	0.46	6	14,350.00	3114.35	6	44.83	1.64	6	17.48	0.77	6	15.00	6.53
556,480	12	7.13	0.41	12	7691.67 <sup>+</sup>	607.53	12	39.05	2.26	12	14.77	0.77	12	15.67	12.47
Control	6	7.38	0.68	6	8633.33	727.25	6	39.47 <sup>+</sup>	3.16	6	15.10	1.23	4	11.00	8.77
178,991	12	7.04 <sup>++</sup>	0.88	12	9533.33	2489.76	12	38.51 <sup>+</sup>	4.63	12	13.95 <sup>++</sup>	1.90	12	14.58	4.61
Control	6	5.46	1.05	6	8416.67	2625.15	5	29.88	6.50	6	10.98	2.00	6	10.67	4.85

Cumulative exposure Ct mg min/m <sup>3</sup>	Band cells			Lymphocytes			Monocytes			Eosinophils			Basophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
		%	%		%	%		%	%		%	%		%	%
1,097,151	-	-	-	10	66.70	13.10	1	1.00	0.00	6	3.50	1.38	-	-	-
Control	-	-	-	6	84.33	7.23	-	-	-	2	2.00	1.00	-	-	-
556,480	-	-	-	12	83.67	12.39	-	-	-	3	2.67	0.94	-	-	-
Control	-	-	-	4	88.50	8.99	-	-	-	1	2.00	0.00	-	-	-
178,991	-	-	-	12	84.67	4.48	3	1.33	0.47	4	1.25	0.43	-	-	-
Control	-	-	-	6	88.83	4.78	-	-	-	2	1.50	0.50	-	-	-

Table B-7. Hematology in Rats 30 Days After 13 Weeks' Exposure to White Phosphorus Smoke

Cumulative exposure Ct	Red blood cells			White blood cells			Hematocrit			Hemoglobin			Neutrophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m <sup>3</sup>		x 10 <sup>6</sup> /mm <sup>3</sup>		per mm <sup>3</sup>	%	%	mg/100 ml	mg/100 ml	%	mg/100 ml	mg/100 ml	%	%	%	%
1,097,151 control	16	7.15	1.0	11,506.25*	40.81	4.55	16	14.48	1.07	16	33.44*	1.07	16	33.44*	16.56
556,480 control	12	7.29	0.71	9558.33	39.31	4.44	12	14.45	1.84	12	20.08	1.84	12	20.08	11.16
178,991 control	24	7.07	0.57	8854.17	36.57	3.00	24	14.44	0.99	24	11.17	0.99	24	11.17	6.38
	12	7.47	0.43	9375.00	44.06	2.39	12	15.02	0.92	12	13.92	0.92	12	13.92	5.12
	12	6.67	0.93	10,913	37.74	4.94	12	14.96	1.86	12	12.42	1.86	12	12.42	5.33
	5	6.61	0.70	11,600.00	36.96	3.91	5	14.74	1.22	5	12.90	1.22	5	12.90	6.60

Cumulative exposure Ct	Band cells			Lymphocytes			Monocytes			Eosinophils			Basophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m <sup>3</sup>		%	%		%	%		%	%		%	%		%	%
	16	1.00	0.00	16	65.75	16.74	2	1.00	0.00	4	2.75	0.83	-	-	-
	12	-	-	12	78.67	11.01	3	1.00	0.00	7	1.57	0.73	-	-	-
	24	-	-	24	88.04	6.26	1	4.00	0.00	13	1.15	0.36	-	-	-
	12	-	-	12	85.58	5.19	-	-	-	5	1.20	0.40	-	-	-
	12	-	-	12	87.00	4.93	-	-	-	4	1.75	0.83	-	-	-
	5	-	-	5	87.20	6.52	-	-	-	3	1.33	0.47	-	-	-

\* Significantly higher than control based on statistical "t" test.  
 \*\* Significantly lower than control based on statistical "t" test.

NOTE: Statistical evaluation of differential-white count components, monocytes, eosinophils, basophils, and band cells may be meaningless since normal occurrences range from 1% to 10%.

Table B-8. Blood Chemistry in Rats Five Weeks' Exposure to White Phosphorus Smoke

Cumulative exposure (Ct)	Glucose			Blood urea nitrogen			Creatinine			Sodium			Potassium		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m <sup>3</sup>		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
499,560 Control	6	150.17*	12.40	6	23.00	3.06	6	0.70	0.08	6	145.17	1.77	6	4.43	0.55
246,285 Control	6	187.17	30.10	6	22.83	2.97	6	0.63	0.09	6	145.50	2.36	6	4.97	1.02
84,019 Control	12	165.83	15.46	12	21.33	1.84	12	0.54	0.12	12	146.58	1.38	12	4.52	0.51
Control	6	171.67	15.88	6	23.83	2.97	6	0.65	0.17	6	147.33	3.25	6	4.47	0.86
Control	11	181.18**	22.39	11	20.64	2.38	11	0.55	0.08	11	145.27	2.18	11	4.25	0.35
Control	6	159.17	8.03	6	19.33	0.75	6	0.50	0.10	6	145.83	1.21	6	4.05	0.35

Cumulative exposure (Ct)	Chloride			Carbon dioxide			Uric acid			Total protein			Albumin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
log min/m <sup>3</sup>		meq/l	meq/l		meq/l	meq/l		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
499,560 Control	6	103.33	1.11	6	21.67	4.31	6	0.85	0.68	6	5.58	0.42	6	3.03	0.32
246,285 Control	6	101.67	1.37	6	22.00	3.83	6	1.37	1.09	6	6.07	0.23	6	3.20	0.15
84,019 Control	12	102.92	2.36	12	22.33	2.39	12	1.32	0.78	12	6.17	0.22	12	3.23	0.12
Control	6	102.87	2.13	6	23.50	4.19	6	1.48	0.84	6	6.05	0.26	6	3.18	0.15
Control	11	103.55	2.23	11	19.09	5.81	11	1.47	1.37	11	5.54	0.53	11	2.76	0.46
Control	6	104.00	2.00	6	22.00	4.62	6	0.73	0.25	6	5.87	0.43	6	3.15	0.24

Cumulative exposure (Ct)	Globulin			Calcium			Phosphate			Cholesterol			Triglycerides		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m <sup>3</sup>		gm/dl	gm/dl		gm/dl	gm/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
499,560 Control	6	2.55	0.28	6	9.77	0.57	6	4.93*	0.65	6	75.00	6.11	6	33.67*	16.60
246,285 Control	6	2.77	0.14	6	10.25	0.43	6	6.07	0.51	6	78.50	11.77	6	69.83	23.02
84,019 Control	12	2.73	0.16	12	9.79	0.36	12	5.93	0.54	12	73.17*	5.98	12	53.58	39.28
Control	6	2.87	0.14	6	9.65	0.17	6	5.90	0.75	6	79.67	4.31	6	89.00	46.63
Control	11	2.57	0.18	11	9.67	0.33	11	5.95	1.13	11	106.18	23.92	11	49.91	37.24
Control	6	2.72	0.27	6	9.87	0.25	6	6.15	0.52	6	97.67	9.84	6	51.83	24.13

Cumulative exposure (Ct)	Alkaline phosphatase			Glutamic oxalacetic transaminase			Glutamic pyruvic transaminase			Lactic dehydrogenase			Total bilirubin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m <sup>3</sup>		u/l	u/l		u/l	u/l		u/l	u/l		u/l	u/l		mg/dl	mg/dl
499,560 Control	6	230.50	51.19	6	147.33	90.76	6	57.33	14.01	6	382.17	297.98	6	0.10	0.00
246,285 Control	6	335.83	99.78	6	119.83	25.47	6	65.67	9.50	6	322.67	88.68	6	0.10	0.00
84,019 Control	12	366.17	139.94	12	120.83	54.22	12	53.08	16.65	12	287.50	173.94	12	0.32	0.39
Control	6	301.00	96.19	6	140.00	81.76	6	59.17	11.99	6	1472.17	2696.11	6	0.10	0.00
Control	11	355.09	90.90	11	126.18	44.53	11	55.09	10.72	11	342.27	173.08	11	0.10	0.00
Control	6	308.60	105.04	6	117.50	53.59	6	49.00	9.45	6	265.67	43.60	6	0.10	0.00

\* Significantly lower than control based on statistical "t" test.  
 \*\* Significantly lower than control based on statistical "t" test.

Table B-9. Blood Chemistry in Rats Bled After 13 Weeks Exposure to White Phosphorus Smoke

Cumulative exposure Ct	Glucose		Blood urea nitrogen		Creatinine		Sodium		Potassium						
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation			
mg min/m <sup>3</sup>		mg/dl	mg/dl		mg/dl	mg/dl		meq/l	meq/l		meq/l	meq/l			
499,560	12	178.58	22.76	12	20.58	4.33	12	0.57	0.07	12	146.61	2.05	12	4.43	0.65
Control	6	168.83	17.35	6	17.50	1.71	6	0.53	0.05	6	147.17	0.69	6	4.28	0.38
246,285	12	166.50	12.27	12	20.33	3.09	12	0.57	0.11	12	144.33	1.60	12	4.07	0.22
Control	6	174.50	14.85	6	21.33	3.14	6	0.63	0.5	6	144.50	0.96	6	4.20	0.58
84,019	12	171.00*	16.87	12	21.67	1.49	12	0.52	0.09	12	145.92	0.86	12	4.18	0.43
Control	6	187.17	7.45	6	21.00	3.58	6	0.57	0.05	6	145.50	0.96	6	4.27	0.36

Cumulative exposure Ct	Chloride		Carbon dioxide		Uric acid		Total protein		Albumin						
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation			
mg min/m <sup>3</sup>		meq/l	meq/l		mg/dl	mg/dl		gm/dl	gm/dl		gm/dl	gm/dl			
499,560	12	106.00	2.68	12	17.58	4.31	12	1.33	1.38	12	5.85	0.27	12	3.30	0.22
Control	6	107.50	0.50	6	17.50	1.71	6	1.05	0.81	6	5.75	0.32	6	3.30	0.14
246,285	12	104.92	2.20	12	19.83	3.13	12	1.23	0.40	12	5.78	0.20	12	3.18	0.11
Control	6	104.67	3.45	6	21.17	3.18	6	1.18	0.64	6	5.90	0.19	6	3.33	0.09
84,019	12	103.56	1.85	12	19.42	2.90	12	0.86	1.13	12	5.80	0.20	12	3.19	0.13
Control	6	104.33	1.97	6	19.00	2.89	6	1.08	0.41	6	5.83	0.25	6	3.10	0.16

Cumulative exposure Ct	Globulin		Calcium		Phosphate		Cholesterol		Triglycerides						
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation			
mg min/m <sup>3</sup>		gm/dl	gm/dl		gm/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl			
499,560	12	2.55	0.13	12	9.68	0.57	12	4.92	1.09	12	111.42	30.22	12	36.25	24.69
Control	6	2.45	0.24	6	9.70	0.24	6	5.08	0.76	6	123.83	12.35	6	57.67	21.01
246,285	12	2.60	0.15	12	9.37	0.23	12	4.70	0.45	12	74.25	9.69	12	31.33	33.24
Control	6	2.57	0.11	6	9.55	0.29	6	5.07	0.53	6	74.33	11.01	6	21.50	20.95
84,019	12	2.61	0.13	12	9.67	0.20	12	5.01	0.52	12	77.92	8.62	12	37.42	24.68
Control	6	2.73	0.19	6	9.43	0.30	6	5.02	0.59	6	77.33	6.05	6	20.67	18.12

Cumulative exposure Ct	Alkaline phosphatase		Glutamic oxalacetic		Glutamic pyruvic		Lactic dehydrogenase		Total bilirubin						
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation			
mg min/m <sup>3</sup>		u/l	u/l		u/l	u/l		u/l	mg/dl		mg/dl	mg/dl			
499,560	12	352.58**	103.00	12	109.08	37.23	12	55.17	13.40	12	290.00	168.56	12	0.10	0.00
Control	6	270.50	48.41	6	85.33	16.36	6	47.17	7.06	6	258.83	85.31	6	0.10	0.00
246,285	12	262.00	72.63	12	91.67	38.87	12	45.75	10.30	12	290.50	117.40	12	0.16	0.05
Control	6	247.67	49.52	6	80.33	9.29	6	40.17	6.12	6	221.33	64.50	6	0.15	0.05
84,019	12	287.42	101.75	12	108.50	30.82	12	58.92	20.54	12	253.67	49.95	12	0.11	0.03
Control	6	295.50	66.50	6	133.67	53.31	6	66.50	15.02	6	411.00	203.72	6	0.12	0.04

\* Significantly lower than control based on statistical "t" test.  
 \*\* Significantly higher than control based on statistical "t" test.

Table B-10. Blood Chemistry in Pats Died 4 Weeks After a 13-week Exposure to White Phosphorus Smoke

Cumulative exposure Ct mg min/m <sup>3</sup>	Glucose			Blood urea nitrogen			Creatinine			Sodium			Potassium		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
499,560	16	173.81	12.53	16	22.25	2.22	16	0.72	0.09	16	147.19*	1.78	16	4.13	0.28
Control	12	175.17	20.32	12	22.67	3.77	12	0.69	0.08	12	145.92	1.04	12	4.08	0.26
246,285	24	180.21	27.87	24	20.04*	1.84	24	0.57	0.07	24	146.42	3.45	24	4.17	0.66
Control	12	168.08	15.26	12	21.58	1.32	12	0.59	0.13	12	147.50	1.55	12	4.05	0.26
84,019	12	196.75	26.54	12	20.33	1.31	12	0.53	0.06	12	145.58	1.66	12	4.51	0.67
Control	5	189.80	20.71	5	18.80	1.17	5	0.56	0.12	5	144.60	1.62	5	4.56	0.69

Cumulative exposure Ct mg min/m <sup>3</sup>	Chloride			Carbon dioxide			Uric acid			Total protein			Albumin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
499,560	16	105.56	1.37	16	19.31	2.52	16	0.98	0.39	16	5.86	0.25	16	3.27	0.18
Control	12	105.83	2.37	12	21.17	2.82	12	1.02	0.70	12	5.92	0.33	12	3.32	0.27
246,285	24	103.42	2.18	24	20.92	2.71	24	1.01	0.67	24	5.64**	0.29	24	3.17**	0.17
Control	12	104.00	2.61	12	20.00	3.46	12	0.76	0.25	12	6.07	0.29	12	3.39	0.22
84,019	12	103.25	1.69	12	25.08	2.25	12	1.35	1.10	12	6.06	0.35	12	3.38	0.12
Control	5	103.40	0.49	5	24.80	0.75	5	1.16	0.63	5	5.88	0.43	5	3.28	0.24

Cumulative exposure Ct mg min/m <sup>3</sup>	Globulin			Calcium			Phosphate			Cholesterol			Triglycerides		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
499,560	16	2.58	0.19	16	9.61	0.27	16	4.69	0.63	16	79.37	18.26	16	49.62	34.81
Control	12	2.59	0.11	12	9.42	0.49	12	4.32	0.81	12	78.33	19.72	12	54.00	34.45
246,285	24	2.47**	0.20	24	9.56	0.54	24	5.17	0.59	24	74.83**	6.54	24	65.92	52.12
Control	12	2.67	0.12	12	9.75	0.42	12	5.01	0.67	12	84.75	13.55	12	94.83	65.87
84,019	12	2.67	0.19	12	10.10	0.24	12	5.33	0.56	12	74.25	9.44	12	56.73	32.14
Control	5	2.60	0.28	5	9.98	0.55	5	5.36	0.33	5	75.60	9.41	5	48.80	16.44

Cumulative exposure Ct mg min/m <sup>3</sup>	Alkaline phosphatase			Glutamic oxaloacetic transaminase			Glutamic pyruvic transaminase			Lactic dehydrogenase			Total bilirubin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
499,560	16	274.69	69.82	16	91.62	26.71	16	48.62	13.72	16	276.06	113.32	16	0.10	0.00
Control	12	299.83	102.99	12	97.83	21.56	12	56.25	11.36	12	305.67	76.71	12	0.10	0.00
246,285	24	262.33	75.80	24	107.92	41.29	24	57.04	25.54	24	323.08	109.66	24	0.10	0.00
Control	12	304.92	88.19	12	110.92	38.15	12	69.50	21.80	12	335.82	61.94	12	0.10	0.00
84,019	12	293.75	90.84	12	126.08	90.45	12	80.00	57.57	12	246.92	88.23	12	0.25	0.14
Control	5	218.00	60.98	5	93.40	17.43	5	58.60	11.57	5	253.80	85.11	5	0.10	0.00

\* Significantly lower than control based on statistical "t" test.  
 \*\* Significantly higher than control based on statistical "t" test.

Table B-11. Teratologic Effects on Pups of Female Rats Euthanized on Day 20 After Inhalation of White Phosphorus/Felt Smoke During Organogenesis

	Dose Level	
	Air controls	589 mg/m <sup>3</sup>
		1,161 mg/m <sup>3</sup>
Number pregnant	20	20
Percent pregnant	100	100
Total implants	238	242
Live implants	225	236
Dead implants	13	6
Percent dead implants	5.46	2.48
Mean weight in grams		
Male	3.91 ± 0.32	3.83 ± 0.36
Female	3.76 ± 0.34	3.67 ± 0.30
Mean body weight - all pups	3.84 ± 0.33	3.76 ± 0.34
Average implants per pregnant female	11.90 ± 1.45	12.10 ± 1.37
Average live implants per pregnant female	11.25 ± 1.41	11.80 ± 1.61
Average dead implants per pregnant female	0.65 ± 0.67	0.30 ± 0.57
		0.83 ± 1.10
		12.28 ± 1.96
		3.87 ± 0.38
		3.66 ± 0.40
		3.77 ± 0.40
		11.44 ± 2.28
		6.79
		15
		206
		221
		90
		18

Table B-12. Reproductive Data for Female Rats Mated to Males Exposed to White Phosphorus/Smoke  
(Numbers in parentheses indicate the number of animals in each category.)

Group	Week	Number mated	Number pregnant	M.I.*	C.L.I.	I.I.	P.I.I.I.	F.I.	R.I.	N.V.F./V.F.	N.V.F.≥1	N.V.F.≥2
Air control	1	20	14	70	(183) 13.07	(165) 11.79	(18) 1.29	(158) 11.29	(7) 0.50	7/158	5/9	2/12
	2	20	19	95	(253) 13.32	(238) 12.53	(15) 0.79	(223) 11.74	(15) 0.79	15/223	9/10	4/15
589 3 mg/m <sup>3</sup>	1	20	19	95	(257) 13.53	(224) 11.79	(33) 1.74	(210) 11.05	(14) 0.74*	14/210	13/6	1/18
	2	20	20	100	(278) 13.90	(259) 12.95	(19) 0.95	(249) 12.45	(10) 0.50	10/249	7/13	3/17
1161 3 mg/m <sup>3</sup>	1	20	18	90	(256) 14.22	(226) 12.56	(30) 1.67	(215) 11.94	(11) 0.61	11/215	8/10	2/16
	2	20	18	90	(255) 14.17	(219) 12.17	(36) 2.00	(215) 11.94	(4) 0.22	4/215	4/14	0/18

\*Abbreviations used

M.I. (mating index) =  $\frac{\text{total number of females pregnant} \times 100}{\text{total number of females mated}}$

C.L.I. (corpus luteus index) =  $\frac{\text{total number of corpora lutea}}{\text{total number of pregnant females}}$

I.I. (implantation index) =  $\frac{\text{total number of implantation sites}}{\text{total number of pregnant females}}$

P.I.I. (pre-implantation loss index) =  $\frac{\text{total number of corpora lutea} - \text{total number of implantation sites}}{\text{total number of pregnant females}}$

F.I. (total index) =  $\frac{\text{total number of viable fetuses}}{\text{total number of pregnant females}}$

R.I. (resorption index) =  $\frac{\text{total number of deaths (early and late)}}{\text{total number of pregnant females}}$

N.V.F./V.F.\* =  $\frac{\text{total number of resorptions}}{\text{total number of viable fetuses}}$

N.V.F.≥1 =  $\frac{\text{total number of females with one or more resorptions}}{\text{total number of females with zero resorptions}}$

N.V.F.≥2 =  $\frac{\text{total number of females with two or more resorptions}}{\text{total number of females with one or zero resorptions}}$

\*Significant at p < 0.05

Table B-13. Viability, Survival, and Lactation Indices in a Single-Generation Study of Reproduction Performance During Exposure to White Phosphorus/Felt Smoke

Index	Generation	Control	Low dose *	High dose **
Viability index	F1	99.48	93.23	64.12
Survival index: day 21	F1	98.44	92.19	30.23
Lactation index	F1	98.95	98.88	47.15

\* Low dose animals exposed to 589 mg/m<sup>3</sup> white phosphorus/felt smoke.

\*\* High dose animals exposed to 1,161 mg/m<sup>3</sup> white phosphorus/felt smoke.

Table B-14. Single-Generation Reproduction Study of White Phosphorus in Cigarette Smoke

Days post-natal	Weight change (mean and SD)					
	Males			Females		
	Control	Low dose*	High dose**	Control	Low dose*	High dose**
1	(103) 6.63 ± 0.57	(90) 7.26 ± 0.74	(136) 6.38 ± 0.62	(89) 6.49 ± 0.69	(102) 6.76 ± 0.75	(166) 6.01 ± 0.69
4	(102) 10.41 ± 1.27	(84) 11.30 ± 1.15	(92) 9.41 ± 1.48	(89) 10.39 ± 1.54	(95) 10.71 ± 1.19	(101) 8.99 ± 1.59
7	(102) 15.36 ± 2.18	(84) 16.66 ± 1.67	(84) 13.97 ± 1.86	(89) 15.45 ± 2.69	(95) 15.64 ± 1.75	(90) 13.62 ± 2.26
14	(100) 29.59 ± 4.19	(83) 31.39 ± 3.52	(47) 26.46 ± 5.03	(89) 29.97 ± 5.31	(94) 29.46 ± 2.72	(44) 25.93 ± 5.53
21	(100) 45.05 ± 8.16	(83) 50.62 ± 5.34	(47) 41.10 ± 9.52	(89) 45.16 ± 9.71	(94) 46.55 ± 5.09	(44) 41.50 ± 11.15

\* Low dose, 589 mg/m<sup>3</sup>.

\*\* High dose, 1,161 mg/m<sup>3</sup>.

Table B-3. Physiological Effects of White Phosphorus Test Solution Pats After 4-Weeks Exposure

Measurement	Units	Exposure										ANOVA			
		Control					Low-Dose					High-Dose		Significance of Ratio	
		All	Males	Females	All	Males	Females	All	Males	Females	Dose	Male x female	Dose: male	Dose: female	
Sample size		12	6	6	22	6	6	6	7	3	3				
Weight	grams	317 ± 54	305 ± 10	259 ± 25	327 ± 78	385 ± 44	256 ± 22	300 ± 54	347 ± 10	252 ± 25		0.001			0.01
Temperature rect.	degrees F	100.1 ± 0.4	100.3 ± 0.3	100.4 ± 0.2	100.2 ± 0.7	100.2 ± 0.8	100.1 ± 0.5	100.7 ± 0.7	100.2 ± 0.5	101.1 ± 0.5*					0.01
Tidal volume	ml	1.75 ± .34	1.96 ± .32	1.55 ± .27	1.96 ± .29	2.05 ± .34	1.84 ± .27	1.68 ± .18	1.82 ± .08	1.53 ± .10					0.001
Minute volume	ml	2.68 ± .47	2.93 ± .32	1.71 ± .47	2.66 ± .37	2.88 ± .28	1.72 ± .27	1.80 ± .45	2.15 ± .28	1.44 ± .19					
Breathing frequency	breaths per minute	107 ± 17	106 ± 21	108 ± 24	103 ± 17	112 ± 14	95 ± 17	106 ± 17	118 ± 11	94 ± 11					0.001
Tidal volume per CO <sub>2</sub>	ml	2.01 ± .40	3.07 ± .28	2.75 ± .46	3.15 ± .65	3.57 ± .47	2.63 ± .15	2.50 ± .42	3.26 ± .18	2.55 ± .14					0.001
Minute volume per CO <sub>2</sub>	ml	4.09 ± .95	4.51 ± .92	3.66 ± .27	4.03 ± 1.31	5.94 ± .59	3.62 ± .99	4.18 ± .97	5.05 ± .27	3.11 ± 0.2					0.05
Breathing frequency per CO <sub>2</sub>	breaths per min	139 ± 23	146 ± 34	137 ± 21	145 ± 19	153 ± 2.4	136 ± 1.1	143 ± 17	155 ± 12	130 ± 7.0					0.01
Blood pressure systolic	mm Hg	118 ± 5	122 ± 4	116 ± 5	120 ± 12	126 ± 11	114 ± 11	115 ± 10	116 ± 12	113 ± 9					
Heart rate - from blood pressure	beats/min	413 ± 61	431 ± 60	435 ± 51	378 ± 39	397 ± 33	359 ± 37	317 ± 35	357 ± 26	394 ± 17					0.01
Heart rate from ECG	beats/min	459 ± 47	465 ± 53	450 ± 48	494 ± 46	516 ± 10*	451 ± 42	397 ± 46*	396 ± 46	399 ± 56					0.01
ECG - P-wave amplitude	mv	0.67 ± 0.29	0.67 ± 0.30	0.67 ± 0.30	0.64 ± 0.32	0.75 ± 0.29	0.73 ± 0.35	0.65 ± 0.19	0.90 ± 0.10	0.80 ± 0.22					
ECG - P-wave duration	sec	0.17 ± 0.02	0.17 ± 0.02	0.17 ± 0.01	0.17 ± 0.02	0.16 ± 0.01	0.17 ± 0.02	0.18 ± 0.02	0.18 ± 0.02	0.17 ± 0.01					
P-R interval	sec	0.16 ± 0.03	0.16 ± 0.04	0.16 ± 0.02	0.16 ± 0.05	0.16 ± 0.04	0.15 ± 0.05	0.16 ± 0.04	0.16 ± 0.04	0.16 ± 0.02					
Q-R-S interval	sec	0.14 ± 0.02	0.14 ± 0.02	0.14 ± 0.02	0.15 ± 0.02	0.15 ± 0.02	0.15 ± 0.02	0.16 ± 0.02	0.16 ± 0.02	0.16 ± 0.02					0.01
Q-T interval	sec	0.37 ± 0.09	0.37 ± 0.08	0.36 ± 0.05	0.37 ± 0.07	0.34 ± 0.08	0.31 ± 0.04	0.35 ± 0.05	0.32 ± 0.02	0.32 ± 0.02					0.05
T-wave amplitude	mv	0.32 ± 0.15	0.35 ± 0.10	0.38 ± 0.20	0.33 ± 0.11	0.20 ± 0.09	0.25 ± 0.12	0.43 ± 0.07	0.47 ± 0.06	0.39 ± 0.07					
T-wave amplitude - width:100	mv	0.13 ± 0.05	0.12 ± 0.04	0.15 ± 0.07	0.12 ± 0.07	0.08 ± 0.07	0.14 ± 0.07	0.15 ± 0.03	0.15 ± 0.04	0.15 ± 0.02					
T-wave:100	mv	0.25 ± 0.10	0.23 ± 0.10	0.23 ± 0.13	0.24 ± 0.13	0.17 ± 0.08	0.13 ± 0.13	0.25 ± 0.15	0.25 ± 0.15	0.25 ± 0.12					

\* Values indicate standard deviation.  
\* Student's 't' test - different from control; at P < 0.05.

Table B-16. Physiological Effects of White Phosphorus/Felt Smoke on Rats After 13 Weeks' Exposure

Measurement	Units	Exposure												Significance of F ratio (A)
		Control			Low-dose			High-dose			Dose x female			
		All	Males	Females	All	Males	Females	All	Males	Females	Dose	Male x female	Dose: male	
Sample size		12	6	6	12	6	6	7	4	3				
Weight	grams	365 ± 83	441 ± 16	268 ± 28	358 ± 103	458 ± 39	257 ± 19	328 ± 78	388 ± 23*	248 ± 30		0.001		0.05
Temperature, rectal	degrees F	99.9 ± .54	99.9 ± .77	100.0 ± .17	100.8 ± .64*	100.1 ± .60	101.5 ± .68**	99.6 ± 0.28	99.7 ± 0.21	99.6 ± 0.40*	0.01			
Tidal volume	ml	2.20 ± .39	2.51 ± .25	1.89 ± .22	1.78 ± .37**	2.06 ± .31*	1.50 ± .12*	1.86 ± .28	1.91 ± .17**	1.79 ± .43	0.05			0.001
Minute volume	ml	215 ± 62	284 ± 43	166 ± 30	185 ± 30	196 ± 34*	174 ± 24	215 ± 28	221 ± 16	207 ± 42	0.05			0.05
Breathing frequency	breaths per minute	97 ± 18	105 ± 12	88 ± 18	106 ± 17	95 ± 16	116 ± 11	117 ± 14**	116 ± 16	117 ± 13	0.01			0.05
Tidal volume, % CO <sub>2</sub>	ml	3.14 ± .48	3.50 ± .31	2.78 ± .31	2.80 ± .52	3.21 ± .37	2.39 ± .21	3.06 ± .38	3.17 ± .35	2.91 ± .43				
Minute volume, % CO <sub>2</sub>	ml	410 ± 93	467 ± 106	371 ± 46	388 ± 60	419 ± 47	358 ± 50	428 ± 83	470 ± 85	373 ± 41		0.001		0.05
Breathing frequency, % CO <sub>2</sub>	b/min	133 ± 22	133 ± 22	134 ± 16	141 ± 20	132 ± 23	149 ± 14	140 ± 21	149 ± 24	129 ± 13		0.01		
Blood pressure, systolic	mm Hg	119 ± 6.0	122 ± 7.1	117 ± 3.2	119 ± 7.6	123 ± 6.3	115 ± 6.4	119 ± 6.1	121 ± 7.6	117 ± 3.6				
Heart rate (from blood pressure)	b/min	389 ± 30	383 ± 29	394 ± 33	456 ± 30*	445 ± 34*	467 ± 44*	418 ± 29	417 ± 21	420 ± 44				
Heart rate (from ECG)	b/min	439 ± 41	432 ± 44	445 ± 39	474 ± 44	464 ± 28	484 ± 57	459 ± 46	440 ± 53	486 ± 16				0.05
ECG - P-wave amplitude	mV	.055 ± .016	.060 ± .027	.050 ± .027	.063 ± .035	.075 ± .072	.060 ± .049	.069 ± .023	.085 ± .010	.047 ± .015				
P-wave duration	sec	.016 ± .002	.017 ± .001	.016 ± .003	.017 ± .001	.018 ± .001	.017 ± .001	.017 ± .001	.017 ± .001	.017 ± .001				
P-P interval	sec	.047 ± .006	.045 ± .004	.049 ± .007	.045 ± .003	.045 ± .002	.045 ± .004	.044 ± .002	.044 ± .002	.043 ± .002				
Q-R-S interval	sec	.016 ± .002	.016 ± .002	.016 ± .001	.016 ± .002	.017 ± .002	.015 ± .002	.016 ± .001	.016 ± .001	.016 ± .001				
Q-T interval	sec	.053 ± .005	.052 ± .005	.053 ± .005	.055 ± .006	.054 ± .002	.055 ± .005	.055 ± .004	.054 ± .005	.055 ± .004				
P-wave amplitude	mV	.24 ± .13	.25 ± .10	.23 ± .17	.36 ± .08	.34 ± .08	.38 ± .08	.24 ± .19	.37 ± .04	.07 ± .15				
T-wave amplitude	mV	.13 ± .05	.12 ± .06	.13 ± .03	.16 ± .05	.15 ± .05	.16 ± .05	.14 ± .04	.16 ± .04	.12 ± .03				0.05
Treadmill run	min	12.6 ± 4.2	10.3 ± 4.9	14.8 ± 1.8	12.8 ± 4.1	12.6 ± 3.8	12.9 ± 4.8	10.9 ± 3.5	11.7 ± 2.5	9.8 ± 5.0				

\* Values indicates standard deviation.

\*\* Student's 't' test - different from control at P = 0.01.

\*\*\* Student's 't' test - different from control at P = 0.05.

\*\*\*\* Student's 't' test - different from control at P = 0.001.

Table B-17. Qualitative Observations on Rats Exposed to White Phosphorous/Felt Smoke

Observation	Number responding					
	Exposure period					
	6 Weeks			13 Weeks		
	Control	Low dose	High dose	Control	Low dose	High dose
Vasomotor reflex	12/12	12/12	6/6	12/12	12/12	7/7
Light reflex	12/12	12/12	6/6	12/12	12/12	7/7
Respiratory response to CO <sub>2</sub>	12/12	12/12	6/6	12/12	12/12	7/7
Sniffing response	9/12	12/12	6/6	11/12	12/12	7/7
Moist rales	0/12	0/12	0/6	0/12	0/12	3/12

Table B-18. Pulmonary Responses of Rats Exposed to White Phosphorus/Felt  
Smoke for 13 Weeks

Condition	Sex	Number of animals	Response (mean and SE)		
			Estimated pulmonary resistance	Respiratory rate	Peak inspiratory flow
			cmH <sub>2</sub> O/l/sec	resp/min	ml/sec
Control	Male	5	1.03 ± 0.06	179 ± 14.3	24.8 ± 0.92
High dose	Male	4	1.29 ± 0.18	171 ± 2.74	24.7 ± 0.70
Low dose	Male	5	1.75 ± 0.27	142 ± 5.07	24.1 ± 0.55
Control	Female	6	1.58 ± 0.88	120 ± 3.3	22.6 ± 0.90
High dose	Female	3	1.75 ± 0.27	145 ± 26.6	24.2 ± 0.59
Low dose	Female	6	1.33 ± 0.13	134 ± 5.8	23.3 ± 0.72

Appendix B

Table B-19. The Spontaneous Activity Responses of Rats Exposed to White Phosphorus/Felt Smoke

Condition	Sex	Number of animals	Response (mean and SE)		Gross activity ratios fine activity	
			Gross activity	Fine activity	from individual data	from mean
6-Week exposure						
Control	Female	6	457 + 143	1680 + 512	5.12 + 1.39	3.68
High dose	Female	3	502 + 21	1739 + 140	3.49 + 0.37	3.46
Low dose	Female	6	574 + 134	1874 + 353	6.32 + 3.40	3.20
Control	Male	6	278 + 122	1093 + 327	5.10 + 0.53	3.93
High dose	Male	3	336 + 65	723 + 319	1.97 + 0.37	2.15
Low dose	Male	6	760 + 109	2253 + 306	3.07 + 0.34	2.96
13-Week exposure						
Control	Female	6	608 + 133	160 + 300	2.82 + 0.46	2.65
High dose	Female	3	462 + 38	1548 + 149	3.42 + 0.53	3.35
Low dose	Female	6	575 + 177	1652 + 421	3.44 + 0.46	2.87
Control	Male	6	601 + 138	1287 + 176	2.40 + 0.29	2.14
High dose	Male	4	420 + 48	1368 + 308	2.86 + 0.54	2.91
Low dose	Male	6	450 + 123	1651 + 191	3.25 + 0.23	3.67

Table B-20. The Passive Avoidance Responses of Rats Exposed to White Phosphorus/Felt Smoke

Condition	Sex	Number of animals	Number of passive avoidance responses (mean and SE)	Total number of shocks (mean and SE)	Time in shock (mean and SE)
<u>6-Week exposure</u>					
Control	Female	6	3.3 ± 0.8	8.3 ± 2.8	0.86 ± 0.23
High dose	Female	3	4.7 ± 1.7	8.7 ± 5.6	0.84 ± 0.52
Low dose	Female	6	3.0 ± 1.0	7.0 ± 1.9	0.73 ± 0.19
Control	Male	6	2.7 ± 0.5	6.2 ± 1.9	0.72 ± 0.25
High dose	Male	3	5.3 ± 1.8	10.3 ± 3.3	1.24 ± 0.12
Low dose	Male	6	2.7 ± 0.5	6.0 ± 1.5	1.73 ± 0.32
<u>13-Week exposure</u>					
Control	Female	6	3.7 ± 0.8	9.3 ± 3.2	0.87 ± 0.35
High dose	Female	3	3.0 ± 0.6	10.7 ± 0.6	1.13 ± 0.15
Low dose	Female	6	7.7 ± 3.3	10.2 ± 2.7	1.21 ± 0.32
Control	Male	6	1.8 ± 0.3	7.0 ± 3.1	1.15 ± 0.64
High dose	Male	4	3.8 ± 1.2	25.5 ± 20.9	2.33 ± 1.89
Low dose	Male	6	2.3 ± 0.6	5.3 ± 2.4	0.55 ± 0.27

## APPENDIX C

### PATHOLOGY REPORT - SPONTANEOUS DEATHS

#### PATHOLOGY REPORT PROJECT SMOKE II, WHITE PHOSPHORUS/FELT INHALATION STUDY - SPONTANEOUS DEATHS "COLONY" RATS

##### I. INTRODUCTION.

Six and thirteen week studies designed to assess potential local and systemic toxic effects of inhalation exposure of the agent White Phosphorus/Felt were performed on Edgewood Area Colony Rats. Three dosage levels of the agent were tested. High (1000 mg/m<sup>3</sup>) dosage level studies began on 31 July 1978. Medium (500 mg/m<sup>3</sup>) dosage level studies began on 7 August 1978. Low (200 mg/m<sup>3</sup>) dosage level studies began on 11 September 1978. All rats were approximately six weeks of age at the beginning of the studies and were housed in Bldg E3266.

Of forty-three rats (19 male, 24 female) receiving the high (1000 mg/m<sup>3</sup>) dosage level exposure to White Phosphorus/Felt, twenty-nine (15 male, 14 female) died spontaneously during the studies while one control animal and none of the medium or low dose group animals died.

Following necropsy, tissues were imbedded in paraffin and subsequently processed for staining with hematoxylin and eosin. The following tissues were evaluated microscopically: nasal turbinate, larynx, trachea, lungs, heart, esophagus, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/teste, uterus, mammary gland, prostate, bone marrow, spleen, brain, eye and pituitary.

Histologic findings are tabulated in Tables 1-3. Since one or more tissues from various animals were lost at necropsy or during processing, one must calculate the incidence of lesions based upon the number of tissues examined rather than on the number of animals necropsied.

Two previous reports have been submitted regarding the histopathological findings in the colony rats that completed the six and thirteen week studies. This report deals only with the histopathological findings in those animals that died spontaneously before completing the studies.

##### II. RESULTS.

The microscopic observations are presented in the Histopathology Incidence Tables.

a. Table 1 tabulates incidence of lesions by organ observed in male and female rats dying spontaneously.

b. Table 2 tabulates incidence and severity of lesions by organ observed in male rats dying spontaneously from the high (1000 mg/m<sup>3</sup>) dosage level exposure group.

c. Table 3 tabulates incidence and severity of lesions by organ observed in female rats dying spontaneously from the high (1000 mg/m<sup>3</sup>) dosage level exposure group.

#### 111. DISCUSSION.

Numerous sporadically occurring lesions were noted in the high (1000 mg/m<sup>3</sup>) dosage level rats that died prior to completion of the White Phosphorus/Felt smoke inhalation studies. Moderate to severe laryngitis was observed in all of nine male rats examined and in five out of six female rats examined. Moderate to severe tracheitis was observed in five out of seven male rats and in all of nine female rats examined. Laryngeal and tracheal lesions often included varying degrees of vesiculation (blistering) and ulceration of the mucosal surfaces. Death of many of these animals probably resulted from asphyxiation produced by mechanical blockage of the larynx/trachea from swelling or from laryngospasm resulting from irritation of the larynx by the smoke. Moderate to severe congestion (hyperemia) was observed in twenty-five out of twenty-nine lungs examined. Irritation produced by the inhaled smoke may be responsible for this finding. A minimal to mild multifocal to diffuse interstitial pneumonia was observed in sixteen out of twenty-nine lungs examined. Peribronchiolar lymphoid aggregates were noted in the lungs of eighteen of twenty-nine animals examined. The interstitial pneumonia and peribronchiolar lymphoid aggregates have been observed historically in colony rats held in this and adjacent animal research facilities. The death of one control rat is attributed to a generalized Phycomycosis (non-contagious fungal agent) involving the gastrointestinal tract, liver and brain.

#### IV. CONCLUSION.

A high mortality rate was noted in the high (1000 mg/m<sup>3</sup>) dosage level exposure group of colony rats being exposed to White Phosphorus/Felt smoke via inhalation exposure. The death of these animals appears to be agent and dose related. A moderate to severe laryngitis/tracheitis accompanied by varying degrees of vesiculation (blistering) and ulceration was observed in most of the animals. Death in these animals probably resulted from asphyxiation produced by mechanical blockage of the larynx/trachea from tissue swelling or from laryngospasm resulting from irritation of the larynx by the smoke. Moderate to severe pulmonary congestion was observed in many of the animals and is probably agent related.



MALCOM N. ALLISON, CPT, VC  
Comparative Pathology Branch  
Veterinary Medicine Division &  
Resources Support Division  
US Army Biomedical Laboratory

Project Smoke II  
White Phosphorus/Felt  
Inhalation Study - Spontaneous Deaths  
"Colony" Rats

Key to Microscopic Findings

Table 1

Number of Animals: Represents total number of animals in each group necropsied.

Numbers following tissues represent the number of tissues from each group actually examined.

Numbers following lesions indicate the number of tissues examined showing the particular lesion.

Tables 2-3

- = tissue present

+ = tissue not available for microscopic evaluation

Numbers following organ: Number of specimens examined

Severity of Response

1 = Minimal

2 = Slight

3 = Moderate

4 = Severe

P = Present

STRAIN OF RAT: COLONY  
 EXPOSURE: VARIABLE  
 AGENT: WHITE PHOSPHORUS/FELT  
 SMOKE II

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS

CONTROL HIGH DOSE

M F M F

NUMBER OF ANIMALS		CONTROL		HIGH DOSE	
		M	F	M	F
NASAL TURBINATE	1/12/11				
Rhinitis, Focal		0	1	15	14
LARYNX	1/9/6				
Laryngitis		1		9	6
Submucosal Gland Duct Ectasia				9	5
TRACHEA	0/7/9				
Tracheitis				7	9
Submucosal Gland Duct Ectasia				5	9
LUNGS	1/15/14				
Pneumonia, Interstitial		1		15	14
Pneumonia, Granulomatous				8	8
Pneumonia, Purulent				1	2
Congestion				12	13
Peribroncholar Lymphoid				9	9
Aggregates					
Bronchitis				3	

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: COLONY  
EXPOSURE: VARIABLE  
AGENT: WHITE PHOSPHORUS/FELT

CONTROL HIGH DOSE  
M F M F

NUMBER OF ANIMALS	CONTROL		HIGH DOSE	
	M	F	M	F
HEART 1/15/14		1		15 14
Myocardial Fibrosis, Focal				
Myocarditis, Focal			2	3
ESOPHAGUS 0/13/13		0		13 13
STOMACH 1/15/14		1		15 14
Gastritis, Acute		1		
SMALL INTESTINE 1/13/13		1		13 13
Enteritis, Acute, Ulcerative		1		
PANCREAS 1/14/14		1		14 14
LARGE INTESTINE 1/14/13		1		14 13
Nematodiasis				
Enteritis, Acute		1		
LIVER 1/14/14		1		14 14
Hepatitis, Focal		1		
Infarct, Lobar				
ADRENAL 1/14/13		1		14 13

STRAIN OF RAT: COLONY  
 EXPOSURE: VARIABLE  
 AGENT: WHITE PHOSPHORUS/FELT  
 TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
 SMOKE II

CONTROL HIGH DOSE

M F M F

NUMBER OF ANIMALS	CONTROL		HIGH DOSE	
	M	F	M	F
THYROID 0/10/13 Degeneration	0		10	13
THYMUS 0/13/7 Hemorrhage, Focal	0		13	7
KIDNEY 1/15/14 Hydronephrosis	1		15	14
Nephritis, Interstitial			2	
Glomerulonephritis			2	1
Tubular Mineralization, Focal				5
Tubular Dilatation, Focal				
Proteinuria			4	5
BLADDER 0/9/14 Perivasculitis	0		9	14
OVARY 0/0/14	0		0	14
UTERUS 1/0/11 Metritis	1		0	11

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY 10011,  
SMOKE II

STRAIN OF RAT: COLONY  
EXPOSURE: VARIABLE  
AGENT: WHITE PHOSPHORUS/FELT

CONTROL      HIGH DOSE  
M F              M F

NUMBER OF ANIMALS	CONTROL		HIGH DOSE	
	M	F	M	F
MAMMARY GLAND 1/0/3	1		0	3
Adenoma				2
Mastitis				
TESTES 0/15/0	0		15	0
PROSTATE 0/11/0	0		11	0
Prostatitis				
MARROW 1/9/8	1			8
Granulopoiesis, Accelerated				
SPLEEN 1/15/14	1		15	14
Hemosiderosis				4
Lymphoid Depletion	1			
BRAIN 1/15/14	1		15	14
Encephalitis, Pyogranulomatous				
Necrosis, Focal	1			13
EYE 1/13/13	1			13
PITUITARY 1/7/4	1			4
Cyst				1

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: COLONY  
EXPOSURE: VARIABLE  
DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
AGENT: WHITE PHOSPHORUS/FELT

MALE

	78-585	78-609	78-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
NASAL TURBINATE	12														
Rhinitis, Focal															
LARYNX	9														
Laryngitis															
Submucosal Gland Duct Ectasia															
TRACHEA	7														
Tracheitis															
Submucosal Gland Duct Ectasia															
LUNGS	15														
Pneumonia, Interstitial															
Pneumonia, Granulomatous															
Pneumonia, Purulent															
Congestion															
Peribronchiolar Lymphoid															
Aggregates															
Bronchitis															

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: COLONY  
EXPOSURE: VARIABLE  
DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
AGENT: WHITE PHOSPHORUS/FELT

MALE

	78-585	78-609	78-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
HEART	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal															
Myocarditis, Focal									1 2						
ESOPHAGUS															
STOMACH															
SMALL INTESTINE															
PANCREAS															
LARGE INTESTINE															
Nematodiasis															
Enteritis, Acute															
LIVER															
Hepatitis, Focal															
Infarct, Lobar															
ADRENAL															

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: COLONY  
EXPOSURE: VARIABLE  
DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
AGENT: WHITE PHOSPHORUS/FELT

MALE

	78-585	78-609	73-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
MAMMARY GLAND	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Adenoma															
Mastitis															
TESTES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROSTATE	+	+	+	-	-	-	-	-	-	-	-	-	-	+	-
Prostatitis															
MARROW	+	-	+	-	+	+	-	+	-	+	-	-	-	-	-
Granulopoesis, Accelerated															
SPLEEN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemosiderosis															
BRAIN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Encephalitis, Pyogranulomatous															
Necrosis, Focal															
EYE	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
PITUITARY	+	+	+	+	+	+	+	-	-	-	+	-	-	-	-
Adenoma															

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: COLONY  
EXPOSURE: VARIABLE  
DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
AGENT: WHITE PHOSPHORUS/FELT

MALE

	78-585	78-609	78-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
THYROID	-	-	-	+	+	-	-	-	-	-	+	+	-	+	-
Degeneration	3	2	1			3	3	2					1		4
THYMUS	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
Hemorrhage, Focal															
KIDNEY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis															
Nephritis, Interstitial										3				1	
Glomerulonephritis															
Tubular Mineralization, Focal															
Tubular Dilatation, Focal	3				2	2				3					
Proteinuria															
BLADDER	-	-	+	-	-	+	+	+	+	-	-	+	-	-	-
Perivasculitis															
Ovary	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
UTERUS	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Metritis															3

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: COLONY  
EXPOSURE: VARIABLE  
DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
AGENT: WHITE PHOSPHORUS/FELT

FEMALE

	78-583	78-614A	78-614B	78-620	78-621	78-622	78-640	78-642	78-643	78-665	78-703	78-709	78-724	78-797
NASAL TURBINATE	11													
Rhinitis, Focal											3	2		
LARYNX	6													
Laryngitis														
Submucosal Gland Duct Ectasia														
TRACHEA	9													
Tracheitis														
Submucosal Gland Duct Ectasia														
LUNGS	14													
Pneumonia, Interstitial														
Pneumonia, Granulomatous														
Pneumonia, Purulent														
Congestion														
Peribronchioal Lymphoid														
Aggregates														
Bronchitis														

STRAIN OF RAT: COLONY  
 EXPOSURE: VARIABLE  
 DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
 AGENT: WHITE PHOSPHORUS/FELT  
 TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
 SMOKE II

FEMALE

	78-583	78-614A	78-614B	78-620	78-621	78-622	78-640	78-642	78-643	78-665	78-703	78-709	78-724	78-797
HEART	14	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal														
Myocarditis, Focal	3			2						2				
ESOPHAGUS	13	-	-	-	+	-	-	-	-	-	-	-	-	-
STOMACH	14	-	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	13	-	-	-	-	-	-	-	-	-	+	-	-	-
PANCREAS	14	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE INTESTINE	13	-	-	-	-	+	-	-	-	-	-	-	-	-
Nematodiasis														
Enteritis, Acute														
LIVER	14	-	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal														
Infarct, Lobar														
ADRENAL	13	-	-	-	+	-	-	-	-	-	-	-	-	-

STRAIN OF RAT: COLONY  
 EXPOSURE: VARIABLE  
 DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
 AGENT: WHITE PHOSPHORUS/FELT

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
 SMOKE II

FEMALE

	78-583	78-614A	78-614B	78-620	78-621	78-622	78-640	78-642	78-643	78-665	78-703	78-709	78-724	78-797
THYROID														
Degeneration	2	1		2	3	2	+	1	2		2	2	3	2
THYMUS														
Hemorrhage, Focal	-	+	+	+	+	-	+	-	-	-	-	+	-	-
KIDNEY														
Hydronephrosis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephritis, Interstitial				1				2						
Glomerulonephritis					2									
Tubular Mineralization, Focal	1	1	1				2	1	1					2
Tubular Dilatation, Focal														
Proteinuria		1	2	1	3		1							
BLADDER														
Perivasculitis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OVARY														
	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UTERUS														
	-	-	-	+	-	-	-	+	-	-	-	-	-	+
Metritis														

STRAIN OF RAT: COLONY  
 EXPOSURE: VARIABLE  
 DOSE LEVEL: HIGH (1000 MG/M<sup>3</sup>)  
 AGENT: WHITE PHOSPHORUS/FEET

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
 SMOKE II

FEMALE

	78-583	78-614A	78-614B	78-620	78-621	78-622	78-640	78-642	78-643	78-665	78-703	78-709	78-724	78-797
MAMMARY GLAND	+	+	+	+	+	+	+	+	-	+	+	+	-	+
Adenoma									P	P				
Mastitis														
TESTES	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PROSTATE	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Prostatitis														
MARROW	-	-	+	-	-	-	-	+	-	+	+	+	+	-
Granulopoiesis, Accelerated														
SPLEEN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemosiderosis	1								1	2	2			
BRAIN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Encephalitis, Pyogranulomatous														
Necrosis, Focal														
EYE	+	-	-	-	-	-	-	-	-	-	-	-	-	-
PITUITARY	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cyst														P

APPENDIX D  
PATHOLOGY REPORT - 6-WEEK EXPOSURE

Project Smoke II  
Inhalation Study Six Weeks  
"Colony" Rats

1. Introduction.

The present study was designed to assess potential local and toxic effects following inhalation exposure to White Phosphorus/Felt for a period of fifteen minutes per day, five days a week, for six weeks.

A group of six female rats were exposed by the inhalation route to White Phosphorus/Felt at a high dose level ( $1000 \text{ mg/m}^3$ ) and two groups of twelve rats, equally divided as to sex, received intermediate ( $500 \text{ mg/m}^3$ ) and low ( $200 \text{ mg/m}^3$ ) dosage levels for the prescribed period of time followed by euthanasia. A fourth group of eighteen rats, equally divided as to sex, that were exposed to air only and maintained under similar conditions, served as controls.

At termination and necropsy, tissues were imbedded in paraffin and subsequently processed for staining with hematoxylin and eosin. The following tissues were evaluated microscopically: nasal turbinate, larynx, trachea, lungs, heart, esophagus, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/teste, uterus, mammary gland, prostate, bone marrow, spleen, brain, eye and pituitary.

2. Results.

The microscopic observations are presented in the Histopathology Incidence Tables.

a. Tables 1-4 tabulate incidence of lesions (by organ) observed in the four groups of male and female colony rats.

b. Tables 5-8 tabulate incidence and severity of lesions (by organ) observed in male and female control rats.

c. Tables 9-12 tabulate incidence of lesions (by organ) observed in each female rat receiving the high dose level exposure to White Phosphorus/Felt.

d. Tables 13-16 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the intermediate dose level exposure to White Phosphorus/Felt.

### 3. Discussion.

A number of spontaneous lesions were noted in the liver, kidney, thyroid, and pituitary; the lesions occurring with equal severity and frequency in control and White Phosphorus/Felt exposed rats. While none of the control animals displayed laryngitis or tracheitis, all of the laryngeal and tracheal specimens examined from the rats receiving the high dosage level of White Phosphorus/Felt displayed a moderate to severe laryngitis/tracheitis. Fifty percent of the rats receiving intermediate dose levels of White Phosphorus/Felt displayed a minimal to mild tracheitis while one out of three rats had a mild laryngitis. Only one rat receiving the low dose level of White Phosphorus/Felt displayed tracheitis. Four out of six female rats receiving the high dose level of White Phosphorus/Felt displayed minimal to severe interstitial pneumonia while one control rat of each sex displayed a minimal interstitial pneumonia.

### 4. Conclusion.

The agent, White Phosphorus/Felt, at the dosage levels tested and in the manner tested show a dose related laryngitis and tracheitis. It is suggestive

that high dosage levels of White Phosphorus/Felt may produce interstitial pneumonia in some animals.



MALCOM N. ALLISON, CPT, VC  
Comparative Pathology & Surgery Group  
Veterinary Medicine Division  
US Army Biomedical Laboratory  
4 September 1979

Project Smoke II  
White Phosphorus Felt  
Inhalation Study Six Weeks  
"Colony" Rats

Key to Microscopic Findings

Tables 1-4

Number of Animals: Represents total number of animals in each group utilized in the study.

Numbers following tissues represent the number of tissues from each group actually examined.

Numbers following lesion indicate the number of tissues examined showing the particular lesion.

Tables 5-16

- = tissue present

\* = tissue not available for microscopic evaluation

Severity of Response

1 = minimal  
2 = slight  
3 = moderate  
4 = severe  
P = present

TABLE 1: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
AGENT: WHITE PHOSPHORUS FELT

	CONTROL		HIGH		INTERMEDIATE		LOW	
	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	9	9	6	6	6	6	6	6
NASAL TURBINATE	7	8			4	3		
Rhinitis, Focal								
LARYNX	7	4		2	0	3	0	2
Laryngitis				2		1		
Submucosal Gland Duct Ectasia	3	2		1		1		1
TRACHEA	3	7		4	6	4	6	3
Tracheitis				4	3	2	1	1
Submucosal Gland Duct Ectasia		2					3	1
LUNGS	9	9		6	6	6	6	6
Pneumonia, interstitial	1	1		4	2	1	1	
Pneumonia, Granulomatous								2
Pneumonia, Purulent				1	2			
Congestion				1				
Peribronchiolar Lymphoid	6	4		3	5	5	3	5
Aggregates								
Bronchitis				3				

TABLE 2: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 7  
AGENT: WHITE PHOSPHORUS FELT

NUMBER OF ANIMALS	CONTROL		HIGH		INTERMEDIATE		LOW	
	M	F	M	F	M	F	M	F
HEART	9	9		6		6		6
Myocardial Fibrosis, Focal		7			1			
Myocarditis, Focal	3						1	
ESOPHAGUS	9	8		5	6	6	6	6
STOMACH	9	9		6	6	5	5	6
SMALL INTESTINE	9	9		5	6	6	6	4
PANCREAS	9	9		6	5	5	6	6
LARGE INTESTINE	9	9		6	6	4	6	6
Nematodiasis	1				1			
Enteritis, Acute								
LIVER	9	9		6	6	6	6	6
Hepatitis, Focal		3						
Infarct, Lobar								
ADRENAL	9	9		6	5	5	6	6

TABLE 3: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE.

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
AGENT: WHITE PHOSPHORUS FELT

	CONTROL		HIGH		INTERMEDIATE		LOW	
	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	9	9	0	6	6	6	5	6
THYROID	8	7		4	5	3	5	6
Degeneration	7	4		2	3	2	2	3
THYMUS	9	7		4	5	5	5	5
Hemorrhage, Focal								
KIDNEY	9	9		6	6	6	6	6
Hydronephrosis	1	1		1				
Nephritis, Interstitial		1						
Glomerulonephritis								
Tubular Mineralization, Focal		6		5		5	1	2
Tubular Dilatation, Focal		1						1
Proteinuria	1	1			1			
BLADDER	7	7		3				
Perivasculitis								
OVARY	0	9		6		5	0	6
UTERUS								
Metritis		8		6		4	0	4
				1				

TABLE 4: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE.

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
AGENT: WHITE PHOSPHORUS FELT

	CONTROL		HIGH		INTERMEDIATE		LOW	
	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	9	9	0	3	0	4	0	1
MAMMARY GLAND								
Adenoma								
Mastitis								
TESTES	9	0		0	6	0	6	0
PROSTATE	9	0		0	4	0	6	0
Prostatitis								
MARRON	6	8		5	4	6	6	6
Granulopoesis, Accelerated	1			1		2		
SPLEEN	9	8		6	6	6	6	6
Hemosiderosis		4		2		3		1
BRAIN	9	9		6	5	6	6	6
Encephalitis, Pyogranulomatous								
Necrosis, Focal								
EYE	7	9		5	5	5	5	6
PITUITARY	5	7		6	4	4	6	6
Adenoma		1						

TABLE 5: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Control  
NECROPSY NO: 78-800/801/731/730/745/746  
AGENT: WHITE PHOSPHORUS FELT

MALE

FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
NASAL TURBINATE	-	*	-	-	-	-	*	-	-	-	-	-	-	-	-	-	*	-	-	-
Rhinitis, Focal																				
LARYNX	*	-	*	-	-	-	-	-	-	-	*	*	-	*	*	-	-	-	*	-
Laryngitis																				
Submucosal Gland Duct Ectasia						1	3	1					3			2				
TRACHEA	-	-	-	*	*	*	*	*	*	*	-	-	*	*	*	*	*	*	*	*
Tracheitis																				
Submucosal Gland Duct Ectasia															1				1	
LUNGS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial						2							2							
Pneumonia, Granulomatous																				
Pneumonia, Purulent																				
Congestion																				
Peribronchiolar Lymphoid																				
Aggregates																				
Bronchitis																				

TABLE 6: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Control  
RECROPSY NO: 78-800/801/731/730/745/746  
AGENT: WHITE PHOSPHORUS FELT

FEMALE

MALE

	FEMALE										MALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal																				
Myocarditis, Focal	2						1	1												
ESOPHAGUS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STOMACH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PANCREAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE INTESTINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nematodiasis																				
Enteritis, Acute																				
LIVER	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal																				
Infarct, Lobar																				
ADRENAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 7: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Control  
NECROPSY NO: 78-800/801/731/730/745/746  
AGENT: WHITE PHOSPHORUS FELT

FEMALE

MALE

	FEMALE										MALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Degeneration	4	3	3	1		2	2	2												
THYMUS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemorrhage, Focal																				
KIDNEY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis																				
Nephritis, Interstitial																				
Glomerulonephritis																				
Tubular Mineralization, Focal																				
Tubular Dilatation, Focal																				
Proteinuria																				
BLADDER	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perivascularitis																				
OVARY																				
UTERUS																				
Metritis																				

TABLE 8: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Control  
NECROPSY NO: 78-800/801/731/730/745/746  
AGENT: WHITE PHOSPHORUS FELT

FEMALE

MALE

	FEMALE										MALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND																				
Adenoma																				
Mastitis																				
TESTES																				
PROSTATE																				
Prostatitis																				
MARROW																				
Granulopoiesis, Accelerated																				
SPLEEN																				
Hemosiderosis																				
BRAIN																				
Encephalitis, Pyogranulomatous																				
Necrosis, Focal																				
EYE																				
PITUITARY																				
Adenoma																				

TABLE 9: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: High  
NECROPSY NO: 78-728/729  
AGENT: WHITE PHOSPHORUS FELT

Appendix D

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
NASAL TURBINATE																				
Rhinitis, Focal																				
LARYNX																				
Laryngitis																				
Submucosal Gland Duct Ectasia																				
TRACHEA																				
Tracheitis																				
Submucosal Gland Duct Ectasia																				
LUNGS																				
Pneumonia, Interstitial																				
Pneumonia, Granulomatous																				
Pneumonia, Purulent																				
Congestion																				
Peribronchiolar Lymphoid																				
Aggregates																				
Bronchitis																				

TABLE 10: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 7  
DOSE LEVEL: High  
RECROPSY NO: 78-728/729  
AGENT: WHITE PHOSPHORUS FELT

MALE

FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART																				
Myocardial Fibrosis, Focal																				
Myocarditis, Focal																				
ESOPHAGUS												*								
STOMACH																				
SMALL INTESTINE												*								
PANCREAS																				
LARGE INTESTINE																				
Nematodiasis																				
Enteritis, Acute																				
LIVER																				
Hepatitis, Focal																				
Infarct, Lobar																				
ADRENAL																				

TABLE 1: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 7  
DOSE LEVEL: High  
NECROPSY NO: 78-728/729  
AGENT: WHITE PHOSPHORUS FELT

MALE FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID																				
Degeneration												*	*	-	-	-	-	-	-	-
THYMUS																				
Hemorrhage, Focal												-	*	-	-	*				
KIDNEY																				
Hydronephrosis												-	-	-	-	-	-	-	-	-
Nephritis, interstitial																				
Glomerulonephritis																				
Tubular Mineralization, Focal																				
Tubular Dilatation, Focal																				
Proteinuria																				
BLADDER																				
Perivasculitis												-	*	*	-	*	*	-	-	-
OVARY																				
												-	-	-	-	-	-	-	-	-
UTERUS																				
Metritis																				

TABLE 12: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
 WEEKS EXPOSURE: 6  
 DAYS POST EXPOSURE: 1  
 DOSE LEVEL: High  
 RECROPSY NO: 78-728/729  
 AGENT: WHITE PHOSPHORUS FELT

MALE FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND											*	-	*	*	-	-				
Adenoma																				
Mastitis																				
TESTES											*	*	*	*	*	*	*	*	*	*
PROSTATE											*	*	*	*	*	*	*	*	*	*
Prostatitis																				
MARROW											-	-	*	-	-	-	-	-	-	-
Granuloposis, Accelerated																				2
SPLEEN											-	-	-	-	-	-	-	-	-	-
Hemosiderosis																1	1			
BRAIN											-	-	-	-	-	-	-	-	-	-
Encephalitis, Pyogranulomatous																				
Necrosis, Focal											-	-	-	-	-	*	-	-	-	-
EYE																				
PITUITARY											-	-	-	-	-	-	-	-	-	-
Adenoma																				

TABLE 13: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Intermediate  
NECROPSY NO: 78-747748  
AGENT: WHITE PHOSPHORUS FELT

Appendix D

MALE FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MASAL TURBINATE	-	*	-	*	-	-	-	-	-	-	-	*	-	*	-	*	-	-	-	-
Rhinitis, Focal																				
LARYNX	*	*	*	*	*	*	*	*	*	*	-	*	-	*	-	*	-	*	-	*
Laryngitis																				
Submucosal Gland Duct Ectasia																				
TRACHEA	-	-	-	-	-	-	-	-	-	-	-	*	-	*	-	*	-	-	-	-
Tracheitis																				
Submucosal Gland Duct Ectasia																				
LUNGS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial																				
Pneumonia, Granulomatous																				
Pneumonia, Purulent																				
Congestion																				
Peribronchiolar Lymphoid																				
Aggregates																				
Bronchitis																				

TABLE 1: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Intermediate  
RECROPSY NO: 78-747742  
AGENT: WHITE PHOSPHORUS FELT

MALE FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal						2														
Myocarditis, Focal																				
ESOPHAGUS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STOMACH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PANCREAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE INTESTINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nematodiasis																				
Enteritis, Acute																				
LIVER	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal																				
Infarct, Lobar																				
ADRENAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 15: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Intermediate  
NECROPSY NO: 78-747/748  
AGENT: WHITE PHOSPHORUS FELT

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID	-	-	*	-	-	-	-	-	-	-	-	*	*	*	-	-	-	-	-	-
Degeneration				4	3	2									4	3				
THYMUS	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*				
Hemorrhage, Focal				1																
KIDNEY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis																				
Nephritis, Interstitial																				
Glomerulonephritis																				
Tubular Mineralization, Focal											2	1	2	1	1					
Tubular Dilatation, Focal																				
Proteinuria						1														
BLADDER	*	*	*	-	-	-	-	-	-	-	-	*	*	*	-	*				
Perivasculitis																				
OVARY														*	-	-	-	-	-	-
UTERUS																				
Metritis																				

TABLE 16: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SHOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Intermediate  
NECROPSY NO: 78-747743  
AGENT: WHITE PHOSPHORUS FELT

MALE

FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND											*	-	-	*	*	*				
Adenoma																				
Mastitis																				
TESTES	-	-	-	-	-	-	-	-	-	-										
PROSTATE	-	*	-	-	-	*														
Prostatitis																				
MARROW	-	*	-	-	-	*														
Granulopoiesis, Accelerated												3				2				
SPLEEN	-	-	-	-	-	-	-	-	-	-										
Hemosiderosis											1	1				1				
BRAIN	-	*	-	-	-	-														
Encephalitis, Pyogranulomatous																				
Necrosis, Focal	-	*	-	-	-	-														
EYE	-	*	*	*	*	*	*	*	*	*										
PITUITARY	-	*	*	*	*	*	*	*	*	*										
Adenoma																				

TABLE 17: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: LOW  
NECROPSY NO: 78-796/798  
AGENT: WHITE PHOSPHORUS FELT

MALE

FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
NASAL TURBINATE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhinitis, Focal																				
LARYNX	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Laryngitis																				
Submucosal Gland Duct Ectasia																				
TRACHEA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tracheitis																				
Submucosal Gland Duct Ectasia	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
LUNGS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial																				
Pneumonia, Granulomatous																				
Pneumonia, Purulent																				
Congestion																				
Peribronchiolar Lymphoid	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aggregates																				
Bronchitis																				

TABLE 18: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE I, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: LOW  
NECROPSY NO: 78-796/798  
AGENT: WHITE PHOSPHORUS-FELT

MALE

FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal																				
Myocarditis, Focal																				
ESOPHAGUS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STOMACH	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-
PANCREAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE INTESTINE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nematodiasis																				
Enteritis, Acute																				
LIVER	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal																				
Infarct, Lobar																				
ADRENAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 19: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE I, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Low  
NECROPSY NO: 78-796/798  
AGENT: WHITE PHOSPHORUS FELT

MALE FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Degeneration	3			2							3	1			2					
THYMUS	*	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Hemorrhage, Focal																				
KIDNEY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis																				
Nephritis, Interstitial																				
Glomerulonephritis																				
Tubular Mineralization, Focal	1														2					1
Tubular Dilatation, Focal																				
Proteinuria																				
BLADDER	-	*	*	-	*	*	*	*	*	*	-	*	*	*	*	*	*	*	*	*
Perivasculitis																				
OVARY																				
UTERUS																				
Metritis																				

TABLE 20: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY  
WEEKS EXPOSURE: 6  
DAYS POST EXPOSURE: 1  
DOSE LEVEL: Low  
NECROPSY NO: 78-796/798  
AGENT: WHITE PHOSPHORUS FELT

MALE

FEMALE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND											*	*	-	*	*	*				
Adenoma																				
Mastitis																				
TESTES	-	-	-	-	-	-	-	-	-	-										
PROSTATE	-	-	-	-	-	-	-	-	-	-										
Prostatitis																				
MARROW	-	-	-	-	-	-	-	-	-	-										
Granuloposis, Accelerated																				
SPLEEN	-	-	-	-	-	-	-	-	-	-										
Hemosiderosis											1									
BRAIN	-	-	-	-	-	-	-	-	-	-										
Encephalitis, Pyogranulomatous																				
Necrosis, Focal																				
EYE	-	-	-	-	-	-	-	-	-	-										
PITUITARY	-	-	-	-	-	-	-	-	-	-										
Adenoma																				

## APPENDIX E

### PATHOLOGY REPORT - 13-WEEK EXPOSURE

#### PATHOLOGY REPORT PROJECT SMOKE II, WHITE PHOSPHORUS/FELT INHALATION STUDY - THIRTEEN WEEKS "COLONY" RATS

##### I. INTRODUCTION.

The study was designed to assess potential local and systemic toxic effects on Edgewood Area Colony rats following inhalation exposure in a chamber to White Phosphorus/Felt for a period of fifteen minutes per day, five days a week, for thirteen weeks. Three separate dosage levels were studied with each dosage level beginning on a different date and having a separate set of control animals receiving sham treatment and housing under similar conditions. All animals were approximately six weeks of age at the beginning of each study. The exposures and animal holding were performed in Bldg E3266.

Exposure of the high dose ( $1000 \text{ mg/m}^3$ ) group began on 31 July and ended on 31 October 1978. The exposed group consisted of eight animals, four of each sex. A separate group of three male and three female controls were utilized. Exposure of the medium dose ( $500 \text{ mg/m}^3$ ) group began on 7 August 1978 and ended on 7 November of that year. Twelve rats, six of each sex, were exposed to the agent. Three male and three female control rats were utilized in this study. Exposure of the low dose ( $200 \text{ mg/m}^3$ ) began on 11 September 1978 and ended on 12 December of the same year. A group of twelve animals, six of each sex, were exposed to the agent. Three male and three female controls were utilized in the study.

In addition to the above animals, a total of four rats, two of each sex, that had been exposed with the high dose group and utilized in physiology studies for eight days were necropsied. No controls were submitted with this group of animals. These animals were included separately in Tables 17-20, but are not considered part of the study in interpreting pathology findings.

Following necropsy, tissues were imbedded in paraffin and subsequently processed for staining with hematoxylin and eosin. The following tissues were evaluated microscopically: nasal turbinate, larynx, trachea, lungs, heart, esophagus, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/teste, uterus, mammary gland, prostate, bone marrow, spleen, brain, eye and pituitary.

Histologic findings are tabulated in Tables 1-20. Since one or more tissues from various animals were lost at necropsy or during processing, one must calculate the incidence of lesions based upon the number of tissues examined rather than on the number of animals necropsied.

## II. RESULTS.

The microscopic observations are presented in the Histopathology Incidence Tables.

a. Tables 1-4 tabulate incidence of lesions (by organ) observed in the six groups of male and female colony rats utilized in the three studies.

b. Tables 5-8 tabulate incidence and severity of lesions (by organ) observed in male and female control rats.

c. Tables 9-12 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the high dose (1000 mg/m<sup>3</sup>) level exposure to White Phosphorus/Felt.

d. Tables 13-16 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the medium dose (500 mg/m<sup>3</sup>) level exposure.


e. Table 17-20 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the low dose (200 mg/m<sup>3</sup>) level exposure.

## III. DISCUSSION.

A number of spontaneous lesions were noted in the liver, kidney, thyroid, spleen, heart, uterus, bladder, mammary glands and large intestine. The lesions occurred either sporadically or with equal frequency and severity in both control and White Phosphorus/Felt exposed rats. While none of the control rats displayed laryngitis or tracheitis, all of the male rats receiving the high dosage level of White Phosphorus/Felt exhibited a moderate laryngitis. Of the female rats receiving the same dosage level (1000 mg/m<sup>3</sup>) of White Phosphorus/Felt, one of two larynges examined displayed a moderate laryngitis while two out of three tracheae displayed mild to moderate tracheitis. Three out of six female rats receiving the medium dosage level of White Phosphorus/Felt displayed a moderate tracheitis while three out of five male rats receiving the same level exposure displayed slight to moderate tracheitis. None of the low dosage level animals displayed laryngitis or tracheitis.

## IV. CONCLUSION.

Though the small number of tissues examined prevents a definitive conclusion, it appears that the agent, White Phosphorus/Felt produces a dose related laryngitis and tracheitis when rats are exposed in the manner tested.

  
MALCOM N. ALLISON, CPT, VC  
Comparative Pathology Group  
Veterinary Medicine Division  
US Army Biomedical Laboratory

Project Smoke II  
White Phosphorus/Felt  
Inhalation Study - Thirteen Weeks  
"Colony" Rats

Key to Microscopic Findings

Tables 1-4

Number of Animals: Represents total number of animals in each group utilized in the study.

Numbers following tissues represent the number of tissues from each group actually examined.

Numbers following lesions indicate the number of tissues examined showing the particular lesion.

Tables 5-20

- = tissue present

+ = tissue not available for microscopic evaluation

Numbers Following Organs: First number is number of tissues from males examined, second number is number of tissues from females.

Severity of Response

1 = Minimal

2 = Slight

3 = Moderate

4 = Severe

P = Present

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
AGENT: White Phosphorus/Feit

	HIGH DOSE				MEDIUM DOSE				LOW DOSE			
	CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED	
	M	F	M	F	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	3	3	4	4	3	3	6	6	3	3	6	6
NASAL TURBINATE	3	2	3	3	3	2	4	6	2	3	6	6
Rhinitis, Focal												
LARYNX	3	2	2	2	0	1	0	0	2	0	1	4
Laryngitis			2	1								4
Submucosal Gland Duct Ectasia	1	1										
TRACHEA	1	2	0	3	3	3	5	6	3	3	5	4
Tracheitis				2			3	3				1
Submucosal Gland Duct Ectasia												
LUNGS	3	3	4	4	3	3	6	6	3	3	6	6
Pneumonia, Interstitial		1	1	1	1	1	1	1				
Pneumonia, Granulomatous												
Pneumonia, Purulent												
Congestion												
Peribroncholar Lymphoid	3	1		2	3	2	5	6	3	2	4	5
Aggregates												
Bronchitis												

STRAIN OF RAT: Colony  
 EXPOSURE: 13 wks  
 AGENT: White Phosphorus/Felt  
 SMOKE II

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS

NUMBER OF ANIMALS	HIGH DOSE						MEDIUM DOSE						LOW DOSE							
	CONTROL			EXPOSED			CONTROL			EXPOSED			CONTROL			EXPOSED				
	M	F		M	F		M	F		M	F		M	F		M	F			
HEART	3	3		4	4		3	3		3	3		3	3		3	3		6	6
Myocardial Fibrosis, Focal																				
Myocarditis, Focal				1												2				
ESOPHAGUS	3	3		3	3		3	3		3	3		3	3		3	3		5	4
STOMACH	2	3		4	4		3	2		3	2		3	3		3	3		6	6
SMALL INTESTINE	3	3		3	4		3	3		3	3		3	3		2	3		6	6
PANCREAS	3	3		4	4		3	2		3	2		3	3		3	3		6	6
LARGE INTESTINE	1	3		3	1		3	3		3	3		3	3		2	3		6	6
Nematodiasis																			1	
Enteritis, Acute																				
LIVER	3	3		4	4		3	3		3	3		3	3		3	3		5	6
Hepatitis, Focal	1			1	1														1	1
Infarct, Lobar																				
ADRENAL	3	3		3	4		2	2		2	2		3	3		3	3		6	6

STRAIN OF RAT: Colony  
 EXPOSURE: 13 wks  
 AGENT: White Phosphorus/Feit

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
 SMOKE II

NUMBER OF ANIMALS	HIGH DOSE						MEDIUM DOSE						LOW DOSE					
	CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F		
THYROID	3	3	4	4	3	3	6	6	3	3	3	3	6	6	3	3		
Degeneration	3	3	3	2	3	2	5	6	3	2	3	2	4	4	3	2		
	3	3	1		3	2	5	6	2	1	2	1	4	4	2	1		
THYMUS	2	3	4	3	3	3	5	5	3	3	3	3	6	6	3	3		
Hemorrhage, Focal																		
KIDNEY	3	3	4	4	3	3	6	6	3	3	3	3	6	6	3	3		
Hydronephrosis																		
Nephritis, Interstitial	1				1				1						1			
Glomerulonephritis																		
Tubular Mineralization, Focal	1		3		1		2		1		2		3		3			
Tubular Dilatation, Focal																		
Proteinuria	1										2							
BLADDER	1	1	4	4	0	1	5	2	3	1	3	1	5	4	3	1		
Perivasculitis																		
OVARY	0	2	0	3	0	3	0	5	0	3	0	3	0	6	0	3		
UTERUS	0	2	0	4	0	2	0	4	0	2	0	4	0	5	0	3		
Metritis																		

TABLE 4 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 12 WKS  
AGENT: White Phosphorus/F212

Appendix E

	HIGH DOSE				MEDIUM DOSE				LOW DOSE			
	CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED	
	M	F	M	F	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	3	0	4	4	3	3	5	6	3	3	6	6
MAMMARY GLAND												
Adenoma												
Mastitis												
TESTES												
	3	0	4	0	3	0	6	0	3	0	6	0
PROSTATE												
Prostatitis												
	0	0	4	0	3	0	6	0	3	0	6	0
MARROW												
Granulopoiesis, Accelerated												
	3	2	4	3	3	3	5	6	3	3	6	6
SPLEEN												
Hemosiderosis												
	2	2	4	4	3	3	6	5	2	3	6	5
BRAIN												
Encephalitis, Pyogranulomatous												
Necrosis, Focal												
	3	3	4	4	3	3	6	5	3	3	6	6
EYE												
PITUITARY												
Adenoma												
	2	2	3	3	3	2	6	6	3	3	6	6

TABLE 5 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 12 wks  
DOSE LEVEL: Control  
AGENT: White Phosphorus/Feit

	MALE						FEMALE					
	HIGH		MED		LOW		HIGH		MED		LOW	
	78-833	78-870	78-959	78-834	78-872	78-956	A	B	C	A	B	C
NASAL TURBINATE	-	-	-	-	-	-	-	-	-	-	-	-
Rhinitis, Focal												
LARYNX												
Laryngitis	-	-	-	-	-	-	-	-	-	-	-	-
Submucosal Gland Duct Ectasia				2								
TRACHEA												
Tracheitis	+	-	-	-	-	-	+	-	-	-	-	-
Submucosal Gland Duct Ectasia												
LUNGS												
Pneumonia, Interstitial	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Granulomatous						2						2
Pneumonia, Purulent												
Congestion												
Peribronchiolar Lymphoid	1	1	2	1	1	1	1	1	1	1	1	2
Aggregates												
Bronchitis												

TABLE 6 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE 11

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks.  
DOSE LEVEL: Control  
AGENT: White Phosphorus/fe't

	MALE						FEMALE											
	HIGH 78-833			MED 78-870			LOW 78-953			HIGH 78-834			MED 78-872			LOW 78-960		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
HEART	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal																		
Myocarditis, Focal																		
ESOPHAGUS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STOMACH	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
PANCREAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE INTESTINE	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Nematodiasis																		
Enteritis, Acute																		
LIVER	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal	1																	
Infarct, Lobar																		
ADRENAL	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 7 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SHOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: Control  
AGENT: White Phosphorus/Fe<sup>2+</sup>

	MALE						FEMALE					
	HIGH		MED		LOW		HIGH		MED		LOW	
	78-833	78-870	78-870	78-870	78-959	78-834	78-872	78-872	78-872	78-960	78-960	
	A	B	C	A	B	C	A	B	C	A	B	C
THYROID	-	-	-	-	-	-	-	-	-	-	-	-
Degeneration	3	3	2	1	1	1	3	3	2	4	2	3
THYMUS												
Hemorrhage, Focal												
KIDNEY												
Hydronephrosis												
Nephritis, Interstitial												
Glomerulonephritis												
Tubular Mineralization, Focal												
Tubular Dilatation, Focal												
Proteinuria												
BLADDER												
Perivasculitis												
OVARY												
UTERUS												
Metritis												

TABLE 6 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: Contro'  
AGENT: White Phosphorus/Felt

	MALE						FEMALE						
	HIGH		MED		LOW		HIGH		MED		LOW		
	A	B	A	B	A	B	A	B	A	B	A	B	C
MAMMARY GLAND	+	+	+	-	+	+	+	+	+	+	-	-	-
Adenoma													
Mastitis													
TESTES	-	-	-	-	-	-	+	+	+	+	+	+	+
PROSTATE	+	+	-	-	-	-	+	+	+	+	+	+	+
Prostatitis													
MARROW	-	-	-	-	-	-	-	-	-	-	-	-	-
Granulopoiesis, Accelerated													
SPLEEN	-	+	-	-	-	-	+	-	-	-	-	-	-
Hemosiderosis													
BRAIN	-	-	-	-	-	-	-	-	-	-	-	-	-
Encephalitis, Pyogranulomatous													
Necrosis, Focal	-	-	-	-	-	-	-	-	-	-	-	-	-
EYE	-	-	-	-	-	-	-	-	-	-	-	-	-
PITUITARY													
Adenoma													

TABLE 9 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: High (1000 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Felt

MALE FEMALE

	78-831				78-874				78-832				78-875	
	A	B	C	D	A	B	C	D	A	B	C	D	A	B
*Animals exposed with this group but held for 8 days for physiology studies prior to necropsy; not included in figures at left or in study.														
NASAL TURBINATE	3	3												
Rhinitis, Focal														
LARYNX	2	2												
Laryngitis	3	3												
Submucosal Gland Duct Ectasia														
TRACHEA	0	3												
Tracheitis														
Submucosal Gland Duct Ectasia														
LUNGS	4	4												
Pneumonia, Interstitial														
Pneumonia, Granulomatous														
Pneumonia, Purulent														
Congestion														
Peribronchiolar Lymphoid	2	2												
Aggregates														
Bronchitis														

TABLE 10 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: High (1000 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Fe<sup>t</sup>

	MALE				FEMALE			
	78-831		78-874		78-832		78-875	
	A	B	C	D	A	B	C	D
HEART	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal								
Myocarditis, Focal			2					
ESOPHAGUS	3/3	-	+	-	-	+	-	-
STOMACH	4/4	-	-	-	-	-	-	-
SMALL INTESTINE	3/4	-	-	+	-	-	-	-
PANCREAS	4/4	-	-	-	-	-	-	-
LARGE INTESTINE	3/1	-	+	-	-	+	-	+
Nematodiasis								
Enteritis, Acute								
LIVER		-	-	-		-	-	-
Hepatitis, Focal								2
Infarct, Lobar								
ADRENAL	3/4	-	-	+	-	-	-	+

\*Animals exposed with this group but held for 8 days for physiology studies prior to necropsy; not included in figures at left or in study.



TABLE 12 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SIOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: High (1000 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Feit

MALE

FEMALE

\*Animals exposed with this group but held for 8 days for physiology studies prior to necropsy; not included in figures at left or in study.

	78-831				78-874				78-832				78-875	
	A	B	C	D	A	B	C	D	A	B	C	D	A	B
MAMMARY GLAND														
Adenoma														
Mastitis														
TESTES	4/0													
PROSTATE	4/0													
Prostatitis														
MARROW	4/3													
Granulopoiesis, Accelerated														
SPLEEN	4/4													
Hemosiderosis	1/1	1/1											2/1	3/2
BRAIN	4/4													
Encephalitis, Pyogranulomatous														
Necrosis, Focal	4/4													
EYE	3/3													
PITUITARY Adenoma														

TABLE 13 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SNOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: Medium (500 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Fe:t

MALE  
78-869  
FEMALE  
78-871

	78-869						78-871					
	A	B	C	D	E	F	A	B	C	D	E	F
HASAL TURBINATE	6/6	-	-	-	+	+	-	-	-	-	-	-
Rhinitis, Focal	4/6	-	-	-	+	+	-	-	-	-	-	-
LARYNX	0/0	+	+	+	+	+	+	+	+	+	+	+
Laryngitis												
Submucosal Gland Duct Ectasia												
TRACHEA	5/6	-	+	-	-	-	-	-	-	-	-	-
Tracheitis		1	2				3	3	3			
Submucosal Gland Duct Ectasia												
LUNGS	6/6	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial												
Pneumonia, Granulomatous												
Pneumonia, Purulent												
Congestion												
Peribronchiolar Lymphoid		1	1	1	2	1	1	1	1	1	1	1
Aggregates												
Bronchitis												

TABLE 14 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: Medium (500 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Feit

Appendix E:

MALE

78-869

FEMALE

78-871

	MALE						FEMALE					
	A	B	C	D	E	F	A	B	C	D	E	F
HEART	6/6	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal												
Myocarditis, Focal	3		1			3						
ESOPHAGUS	4/6	-	+	-	-	+	-	-	-	-	-	-
STOMACH	6/6	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	5/4	-	-	-	-	+	-	-	+	-	-	+
PANCREAS	5/6	-	-	-	-	+	-	-	-	-	-	-
LARGE INTESTINE	6/6	-	-	-	-	-	-	-	-	-	-	-
Nematodiasis												
Enteritis, Acute												
LIVER	5/6	+	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal												
Infarct, Lobar												
ADRENAL	5/6	-	-	-	-	-	-	-	-	-	-	-

TABLE 15 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: Medium (500 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Felt

MALE 78-869 FEMALE 78-871

	MALE						FEMALE					
	A	B	C	D	E	F	A	B	C	D	E	F
THYROID	6/6	-	+	-	-	-	-	-	-	-	-	-
Regeneration	5/6	2	2	1	4	2	3	2	3	3	3	3
THYMUS	5/5	-	-	-	+	-	-	+	-	-	-	-
Hemorrhage, Focal												
KIDNEY	6/6	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis												
Nephritis, Interstitial												
Glomerulonephritis												
Tubular Mineralization, Focal												
Tubular Dilatation, Focal												
Proteinuria		1		1								2
BLADDER	5/2	-	-	+	-	-	+	-	-	+	+	+
Perivesculitis												
OVARY	0/5						+	-	-	-	-	-
UTERUS	0/5						-	-	-	+	-	-
Metritis												1

TABLE 16 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: Medium (500 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Felt

MALE

78-869

FEMALE

78-871

	MALE						FEMALE					
	A	B	C	D	E	F	A	B	C	D	E	F
MAMMARY GLAND	6/6											
Adenoma	0/3											
Mastitis												
TESTES	6/0											
PROSTATE	6/0											
Prostatitis												
MARROW	5/6											
Granulopoiesis, Accelerated												
SPLEEN	6/5											
Hemosiderosis												
BRAIN	6/6											
Encephalitis, Pyogranulomatous												
Necrosis, Focal	6/5											
EYE	6/6											
PITUITARY												
Adenoma												

TABLE 17: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
 EXPOSURE: 13 wks  
 DOSE LEVEL: Low (200 mg/m<sup>3</sup>)  
 AGENT: White Phosphorus/Fc't

MALE FEMALE

	78-957						78-958					
	A	B	C	D	E	F	A	B	C	D	E	F
NASAL TURBINATE	6/6	-	-	-	-	-	-	-	-	-	-	-
Rhinitis, Focal												
LARYNX	1/4	+	+	+	+	+	+	+	+	+	+	+
Laryngitis							2					
Submucosal Gland Duct Ectasia							2					
TRACHEA	5/4	-	+	-	-	-	-	-	-	-	-	-
Tracheitis												
Submucosal Gland Duct Ectasia						3						
LUNGS	6/6	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial							1	1				2
Pneumonia, Granulomatous												
Pneumonia, Purulent												
Congestion												
Peribronchiolar Lymphoid		1	1	1	2		1	1	2	1	1	
Aggregates												
Bronchitis												

STRAIN OF RAT: Co only  
 EXPOSURE: 13 wks  
 DOSE LEVEL: Low (200 mg/m<sup>3</sup>)  
 AGENT: White Phosphorus/Fe<sup>2+</sup>

TABLE 15: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RA-5  
 SMOKE II

MALE

FEMALE

78-957

78-958

	MALE						FEMALE					
	A	B	C	D	E	F	A	B	C	D	E	F
HEART	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal												
Myocarditis, Focal					1							
ESOPHAGUS	5/4	-	-	-	+	-	-	-	-	-	+	-
STOMACH	6/6	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	6/6	-	-	-	-	-	-	-	-	-	-	-
PANCREAS	6/6	-	-	-	-	-	-	-	-	-	-	-
LARGE INTESTINE	6/6	-	-	-	-	-	-	-	-	-	-	-
Nematodiasis												
Enteritis, Acute												
LIVER	6/6	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal												
Infarct, Lobar												
ADRENAL	6/6	-	-	-	-	-	-	-	-	-	-	-

TABLE 19 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE II

STRAIN OF RAT: Colony  
EXPOSURE: 13 w/s  
DOSE LEVEL: Low (200 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Felt

MALE 78-957 FEMALE 78-958

	MALE						FEMALE					
	A	B	C	D	E	F	A	B	C	D	E	F
THYROID	-	+	-	+	-	-	-	+	-	-	-	+
Degeneration	2	2	2	2	2	2	2	1	1	1	2	2
THYRUS	-	-	-	-	-	-	-	-	-	-	-	-
Hemorrhage, Focal												
KIDNEY	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis												
Nephritis, Interstitial												
Glomerulonephritis												
Tubular Mineralization, Focal												
Tubular Dilatation, Focal												
Proteinuria												
BLADDER	-	-	-	-	+	-	-	-	-	+	-	-
Perivasculitis												
OVARY												
UTERUS												
Metritis												

TABLE 20 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS  
SMOKE 11

STRAIN OF RAT: Colony  
EXPOSURE: 13 wks  
DOSE LEVEL: Low (200 mg/m<sup>3</sup>)  
AGENT: White Phosphorus/Felt

Appendix E

MALE

78-957

FEMALE

78-958

	MALE						FEMALE					
	A	B	C	D	E	F	A	B	C	D	E	F
MAMMARY GLAND												
Adenoma												
Mastitis												
TESTES												
PROSTATE												
Prostatitis												
MARROW												
Granulopoiesis, Accelerated												
SPLEEN												
Hemosiderosis												
BRAIN												
Encephalitis, Pyogranulomatous												
Necrosis, Focal												
EYE												
PITUITARY												
Adenoma												

101/102

## APPENDIX F

### PATHOLOGY REPORT - 13-WEEK EXPOSURE AND 4-WEEK RECOVERY PERIOD

PATHOLOGY REPORT  
PROJECT SMOKE II, WHITE PHOSPHORUS/FELT  
INHALATION STUDY PERFORMED FOR THIRTEEN WEEKS IN  
EDGEWOOD COLONY RATS  
PROTOCOL NO. PEM 78-7

#### 1. INTRODUCTION.

Male and female Edgewood area colony rats approximately six weeks old were exposed to high ( $1000 \text{ mg/m}^3$ ), medium ( $500 \text{ mg/m}^3$ ) and low ( $200 \text{ mg/m}^3$ ) dose levels of the agent White Phosphorus/Felt in the form of smoke. The above doses were administered 15 minutes a day, 5 days a week for a period of thirteen weeks. Thirty days following final exposure, the rats were killed by intraperitoneal injection of sodium pentobarbital and necropsied. Since each dose group was exposed on different calendar dates, separate control groups were utilized with each exposure group. Controls were placed in the exposure chamber for the same length of time each day as the exposed animals. Controls were necropsied concurrently with the exposed groups. All animals were housed in Building E3266 in standard laboratory animal facilities during non-exposure periods. Following necropsy, tissues were fixed in ten percent buffered formalin. The preserved tissues were submitted to the American HistoLab, for imbedding in paraffin, processing, and staining with hematoxylin and eosin. The following tissues from the high dose group and controls were processed for microscopic examination: nasal turbinate, larynx/trachea, lungs, heart, esophagus, salivary gland, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/testis, uterus, mammary gland, skin, muscle, prostate, bone marrow, bone, spleen, nerve, eye, brain, and pituitary. Turbinates were removed at necropsy for processing. The trachea was sampled from the proximal portion and lungs were sectioned randomly. The respiratory tracts only (target organ) consisting of nasal turbinates, trachea, larynx, and lungs were examined in medium and low dose groups.

#### 2. RESULTS.

Significant findings were limited to the respiratory tract. These data are presented in Tables 1-3. Microscopic diagnoses from all tissues of high dose and control rats are presented in Tables 4-7. Respiratory tract lesions are presented from all other animals in Tables 8-13. Lesions were noted in the larynx or trachea of 15 of 16 high ( $1000 \text{ mg/m}^3$ ) dose level rats, 20 of 24 medium dose ( $500 \text{ mg/m}^3$ ) level rats and in none of the controls. Pulmonary lesions were noted in 11 of 16 high dose rats, 6 of 24 medium dose rats and none of the controls for these two groups. Although none of the low dose animals exhibited significant lesions, one control (79-0176) for this group did display the same pulmonary lesion as the high and medium dose exposed animals. Lesions were most extensive and severe in the larynx and trachea. They consisted mainly of thickening of the lamina propria and submucosa by collagen, endothelial cell proliferation, and macrophage infiltration. Areas of collagen were tinctorially different and characterized by an amphophilic to basophilic appearance. Epithelioid macrophages with giant cell formation surrounded some of the altered collagen. Overlying epithelium often lacked cilia and was at times thickened and metaplastic. Occasionally, inflammatory cells were seen

in the epithelium. Similar but much less extensive lesions were seen in bronchi and bronchioles. These lesions were characterized by focal areas of altered collagen within the lamina propria. These foci were amphophilic to basophilic in appearance and occasionally surrounded by macrophages and epithelioid giant cells. Small granulomas were noted within respiratory bronchioles. These granulomas often extended into the adjacent lung parenchyma. The granulomas were characterized by swirling configurations of histiocytes and epithelioid macrophages with giant cell formation.


### 3. DISCUSSION.

A number of incidental lesions were observed in various organs of the high (1000 mg/m<sup>3</sup>) dose group. These lesions either occurred sporadically or with equal frequency in both exposed and control animals. Smoke-related lesions were limited to the upper airways and to a lesser extent, the smaller airways of the lung and the parenchyma adjacent to the terminal bronchioles. Since only the respiratory system was involved in the high dose animals, examination was confined to this system in the medium and low dose groups. All lesions attributable to the smoke were of a chronic inflammatory nature, characterized by collagen degeneration, and thickening of the lamina propria and submucosa of airways by fibrovascular proliferations.

Nasal lesions consisting of focal squamous metaplasia and a slight inflammatory cell infiltrate were seen in one high dose animal, accession number 78-910F. It is felt that lesions may have been present in other exposed animals as well; however, the sampling technique precluded our observing this. In light of this, it is recommended that a more systematic approach to studying the upper respiratory tract lesions be followed in subsequent studies.

### 4. CONCLUSION.

Rats exposed to the agent, White Phosphorus/Felt at the 1000 mg/m<sup>3</sup> and 500 mg/m<sup>3</sup> dosage levels developed a dosage related response characterized by chronic inflammation of the airways; lesions were most severe in the larynx and trachea but also involved the lower areas to a slight degree.

  
MALCOM N. ALLISON, CPT, VC  
Comparative Pathology Branch  
Veterinary Medicine & Laboratory  
Resources Support Division  
US Army Biomedical Laboratory  
30 May 1980

REVIEWED BY:


  
WILLIAM C. HALL, MAJ, VC  
U.S. Army  
USAMRIID



TABLE 2 MICROSCOPIC OBSERVATIONS FROM RESPIRATORY TISSUES FROM  
 EDGEWOOD AREA COLONY RATS EXPOSED TO WHITE PHOSPHORUS/FELT  
 SMOKE FOR 13 WEEKS AND KILLED 30 DAYS POST EXPOSURE

PROTOCOL NO. PEM 78-7	SEX	MALE		FEMALE	
		500PPH	CONTROL	500PPH	CONTROL
ACCESSION NO.		78-926	78-927	78-929	78-930
NO. OF RATS		12	6	12	6
<u>DIAGNOSIS</u>					
Laryngitis/Tracheitis		10	0	10	0
Bronchitis/Bronchiolitis		4	0	1	0
Granulomatous Bronchitis/Pneumonia		0	0	1	0

TABLE 3 MICROSCOPIC OBSERVATIONS FROM RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS EXPOSED TO WHITE PHOSPHORUS/FELT SMOKE FOR 13 WEEKS AND KILLED 30 DAYS POST EXPOSURE

PROTOCOL NO. PEM 78-7	SEX	MALE		FEMALE	
		200PPM	CONTROL	200PPM	CONTROL
ACCESSION NO.		79-017	79-017	79-016	79-018
NO. OF RATS		6	3	6	2
<u>DIAGNOSIS</u>					
Laryngitis/Tracheitis		0	0	0	0
Bronchitis/Bronchiolitis		0	0	0	0
Granulomatous Bronchiolitis/Pneumonia		0	1	0	0

PROTOCOL NO.: PEM 78-7  
SEX: MALE  
EXPOSURE: CONTROL  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

TABLE 4 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

Appendix F

ACCESSION NO.

DIAGNOSIS

78-912A

Histocytosis, focal, minimal, pleura, lung, rat  
Nephrosis, multifocal, minimal to mild, kidney  
Congestion, minimal, thymus

78-912B

Congestion, mild, lung, rat  
Hemorrhage and congestion, minimal, thymus

78-912C

Pyelitis, focal, acute, minimal, kidney, rat  
Hemorrhage and congestion, diffuse, mild, thymus

78-912D

Congestion, multifocal, mild, lung, rat  
Chronic respiratory disease, minimal, lung & bronchus  
Congestion and hemorrhage, diffuse, minimal, thymus

78-912E

Congestion, multifocal, mild, lung, rat  
Chronic respiratory disease, minimal, lung  
Hemorrhage, multifocal, minimal, thymus

78-912F

Lymphoid infiltrate focal, minimal, subplural, lung, rat  
Chronic respiratory disease, minimal, lung  
Congestion, diffuse, minimal, thymus  
Hemorrhage, multifocal, minimal, thymus  
Medial calcification, focal, minimal, pulmonary artery

TABLE 5 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: FEMALE  
EXPOSURE: CONTROL  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

<u>ACCESSION NO.</u>	<u>DIAGNOSIS</u>
78-914A	Histiocytosis, focal, minimal, lung, rat Nephrocalcinosis, minimal, kidney Hemorrhage, multifocal, minimal, thymus
78-914B	Congestion, multifocal, mild, lung, rat Nephrocalcinosis, minimal, kidney Hemorrhage, multifocal, minimal, thymus
78-914C	Nephrocalcinosis, minimal, kidney, rat
78-914D	Congestion, multifocal, mild, lung, rat Retinal atrophy, focal, minimal, eye Endocardiosis, valvular, minimal, heart
78-914E	Tracheitis, focal, lymphocytic, minimal, trachea, rat Chronic respiratory disease, minimal, lung Congestion, focal, minimal, lung Granuloma, focal, Hardarian gland Congestion, diffuse, moderate, thymus

TABLE 5 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: FEMALE  
EXPOSURE: CONTROL  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

ACCESSION NO.

78-974F

DIAGNOSIS

Congestion, focal, minimal, lung, rat  
Congestion and hemorrhage, diffuse, mild, thymus  
Congestion, moderate, lymph node

TABLE 6 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: MALE  
EXPOSURE: 1000 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

ACCESSION NO.

DIAGNOSIS

Tracheitis, chronic, diffuse, moderate, trachea, rat  
 Interstitial pneumonia, multifocal, mild, lung  
 Congestion, diffuse, minimal, spleen

78-910A

Tracheitis, chronic, diffuse, mild, trachea, rat  
 Prostatitis, interstitial, subacute, diffuse, minimal-mild, prostate  
 Epicarditis, subacute, focal, mild, rt. ventricle, heart

78-910B

Tracheitis, chronic, diffuse, mild, trachea, rat  
 Prostatitis, interstitial, subacute, diffuse, minimal, prostate  
 Nematodiasis, large intestine, compatible with Oxyuriasis

78-910C

Tracheitis, subacute, diffuse, moderate-severe, trachea, rat  
 Pneumonia, granulomatous, multifocal, minimal, lung  
 Prostatitis, subacute, multifocal, minimal, prostate  
 Congestion, diffuse, minimal, thymus

78-910D

TABLE 6 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE I

PROTOCOL NO.: PEM 78-7  
SEX: MALE  
EXPOSURE: 1000 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

Appendix F

ACCESSION NO.

DIAGNOSIS

78-910E

Tracheitis, chronic, multifocal, mild, trachea, rat  
Laryngitis, chronic, multifocal, mild, larynx  
Bronchitis, chronic, multifocal, mild, lung  
Rhinitis, focal, subacute, mild, nasal cavity  
Myocarditis, focal, subacute, minimal, heart  
Congestion, diffuse, mild, spleen

78-910F

Tracheitis, multifocal, chronic, mild, trachea, rat  
Pneumonia, granulomatous, multifocal, minimal, lung  
Bronchitis, multifocal, chronic, minimal, lung  
Prostatitis, interstitial, multifocal, minimal, prostate  
Congestion, and hemorrhage, diffuse, mild, thymus

78-910G

Tracheitis, multifocal, chronic, minimal, trachea, rat  
Bronchiolitis, chronic, multifocal, minimal, lung  
Prostatitis, subacute, multifocal, mild, prostate

78-910H

Laryngitis, chronic, diffuse, minimal, larynx, rat  
Pneumonia, granulomatous, multifocal, minimal, lung  
Hemorrhage, focal, minimal, thymus, rat

TABLE 6 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: MALE  
EXPOSURE: 1000 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

Appendix F

ACCESSION NO.  
78-9107

DIAGNOSIS

Laryngitis, diffuse, chronic, mild, larynx, rat  
Pneumonia, granulomatous, multifocal, minimal, lung  
Bronchiolitis, obliterative, focal, lung  
Bronchiolitis, multifocal, chronic, minimal  
Congestion, diffuse, mild, thymus  
Congestion, diffuse, minimal, spleen

TABLE 7 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: FEMALE  
EXPOSURE: 1000 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

Appendix F

ACCESSION NO.

78-913A

DIAGNOSIS

Tracheitis, chronic, multifocal, mild, trachea, rat  
Hemorrhage, multifocal, minimal, thymus  
Congestion, multifocal, mild, lung  
Nephrocalcinosis and lithiasis, mild, kidney

78-913B

Laryngitis, multifocal, chronic, mild, larynx, rat  
Bronchitis, multifocal, chronic, minimal, lung  
Pneumonia, granulomatous, focal, minimal, lung  
Nephrocalcinosis, minimal, kidney  
Atrophy, focal, minimal, retina, eye  
Congestion, and hemorrhage, diffuse, minimal, thymus

78-913C

Bronchitis, focal, chronic, minimal, lung, rat  
Congestion, and hemorrhage, diffuse, mild, thymus  
Myocarditis, focal, subacute, minimal, Rt. ventricle, heart  
Nephrocalcinosis, minimal, kidney

PROTOCOL NO.: PEM 78-7  
SEX: FEMALE  
EXPOSURE: 1000 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

TABLE 7 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

Appendix F

ACCESSION NO.

DIAGNOSIS

78-913D

Laryngitis, subacute, multifocal, minimal, larynx, rat  
Histiocytosis, multifocal, minimal, lung  
Hemorrhage, diffuse, moderate, lymph node  
Congestion, and hemorrhage, diffuse, mild, thymus

78-913E

Tracheitis, chronic, focal, minimal, trachea, rat  
Lymphoid infiltrate: focal, minimal, subpleural, lung  
Histiocytosis, focal, minimal, lung, rat  
Congestion, and hemorrhage, diffuse, mild, thymus  
Nephrocalcinosis, minimal, kidney  
Mineralization, focal, minimal, adrenal

78-913F

Tracheitis, focal, chronic, minimal, trachea, rat  
Congestion, diffuse, mild, thymus  
Cyst, thymus  
Hemorrhage, diffuse, moderate, lymph node  
Nephrocalcinosis, mild, kidney

TABLE 7 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: FEMALE  
EXPOSURE: 1000 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

Appendix F

DIAGNOSIS

Laryngitis, multifocal, chronic, minimal, larynx, rat  
Pneumonia granulomatous, multifocal, minimal, lung  
Chronic respiratory disease, minimal  
Congestion, diffuse, mild, lung  
Medial calcification, multifocal, minimal, pulmonary artery  
Hemorrhage and congestion, thymus

ACCESSION NO.

78-9136

PROTOCOL NO.: PEM 78-7      TABLE 8    MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
 SEX: MALE  
 EXPOSURE: CONTROL  
 AGENT: WHITE PHOSPHORUS/FELT  
 LENGTH OF EXPOSURE: 13 WEEKS  
 POST EXPOSURE: 30 DAYS

SMOKE II

Appendix F

ACCESSION NO.

DIAGNOSIS

78-927A

Congestion, mild, lung, rat

78-927B

Congestion, mild, lung, rat

78-927C

No significant lesion

78-927D

Medial calcification, focal, minimal, pulmonary artery, rat

78-927E

Congestion, mild, lung, rat  
 Medial calcification, multifocal, minimal, pulmonary artery  
 Chronic respiratory disease, mild, lung

78-927F

Lymphoid infiltrate, focal, minimal, pleura, lung, rat  
 Congestion, minimal, lung

TABLE 9 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: MALE  
EXPOSURE: 500 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

ACCESSION NO.

DIAGNOSIS

78-926A	Tracheitis, chronic, diffuse, mild, trachea, rat Bronchiolitis, focal, chronic, minimal, lung Medial calcification, focal, minimal, pulmonary artery, lung
78-926B	No significant lesion
78-926C	Tracheitis, diffuse, chronic, moderate, trachea, rat Bronchitis, focal, chronic, minimal, lung
78-926D	Tracheitis, diffuse, chronic, moderate, trachea, rat Bronchitis, multifocal, chronic, minimal, bronchi Chronic respiratory disease, minimal, lung Medial calcification, multifocal, minimal, pulmonary artery, lung
78-926E	Tracheitis, focal, chronic, moderate, trachea, rat Medial hypertrophy, multifocal, moderate, pulmonary artery, lung
78-926F	Laryngitis, diffuse, chronic, mild, larynx, rat

PROTOCOL NO.: PEM 78-7      TABLE 9      MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
 SEX: MALE  
 EXPOSURE: 500 MG/M<sup>3</sup>  
 AGENT: WHITE PHOSPHORUS/FELT  
 LENGTH OF EXPOSURE: 13 WEEKS  
 POST EXPOSURE: 30 DAYS

Appendix F

<u>ACCESSION NO.</u>	<u>DIAGNOSIS</u>
78-926G	Tracheitis, diffuse, chronic, moderate, trachea, rat
78-926H	Bronchiolitis, focal, chronic, minimal, lung, rat
78-926I	Tracheitis, multifocal, chronic, moderate, trachea, rat Histiocytosis, multifocal, minimal, lung
78-926J	Laryngitis, multifocal, chronic, minimal, larynx, rat Medial calcification, focal, minimal, pulmonary artery, lung
78-926K	Tracheitis, multifocal, chronic, moderate, trachea, rat
78-926L	Tracheitis, focal, chronic, mild, trachea, rat

TABLE 10 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: FEMALE  
EXPOSURE: 500 MG/M<sup>3</sup>  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

<u>ACCESSION NO.</u>	<u>DIAGNOSIS</u>
78-929A	Tracheitis, multifocal, chronic, minimal, trachea, rat Bronchiolitis, granulomatous, focal, minimal, lung
78-929B	Interstitial pneumonia, focal, minimal, lung, rat
78-929C	Essentially normal tissues, rat
78-929D	Tracheitis, focal, chronic, minimal, trachea, rat
78-929E	Laryngitis, focal, chronic, minimal, larynx, rat
78-929F	Tracheitis, diffuse, chronic, moderate, trachea, rat
78-929G	Laryngitis, focal, chronic, minimal, larynx, rat
78-929H	Laryngitis, focal, chronic, minimal, trachea, rat
78-929I	Laryngitis, focal, chronic, mild, larynx, rat
78-929J	Tracheitis, multifocal, chronic, minimal, trachea, rat

PROTOCOL NO.: PEM 78-7      TABLE 10      MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
SEX: FEMALE      SMOKE II  
EXPOSURE: 500 MG/M<sup>3</sup>

AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

Appendix F

DIAGNOSIS

Tracheitis, multifocal, chronic, minimal, trachea, rat  
Laryngitis, diffuse, chronic, minimal, larynx, rat  
Bronchiolitis, focal, chronic, minimal, lung

ACCESSION NO.

78-929K  
78-929L

PROTOCOL NO.: PEM 78-7 TABLE 11 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

SEX: FEMALE  
EXPOSURE: CONTROL  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

<u>ACCESSION NO.</u>	<u>DIAGNOSIS</u>
78-930A	Histiocytosis, focal, minimal, lung, rat Chronic respiratory disease, minimal, lung
78-930B	Chronic respiratory disease, minimal, lung, rat
78-930C	Histiocytosis, multifocal, mild, lung, rat Chronic respiratory disease, lung
78-930D	Histiocytosis, multifocal, minimal, lung, rat Chronic respiratory disease, minimal, lung
78-930E	Histiocytosis, multifocal, minimal, lung, rat Chronic respiratory disease, lung

PROTOCOL NO.: PEM 78-7      TABLE 12      MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
 SEX: MALE  
 EXPOSURE: 200 MG/M<sup>3</sup>  
 AGENT: WHITE PHOSPHORUS/FELT  
 LENGTH OF EXPOSURE: 13 WEEKS  
 POST EXPOSURE: 30 DAYS

Appendix F<sub>1</sub>

<u>ACCESSION NO.</u>	<u>DIAGNOSIS</u>
79-15A	No significant lesions
79-15B	No significant lesions
79-15C	No significant lesions
79-15D	No significant lesions
79-15E	No significant lesions
79-15F	No significant lesions

TABLE 13 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

PROTOCOL NO.: PEM 78-7  
SEX: MALE  
EXPOSURE: CONTROL  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

Appendix F

<u>ACCESSION NO.</u>	<u>DIAGNOSIS</u>
79-17A	Histiocytosis, focal, minimal, lung, rat Congestion, minimal, lung Chronic respiratory disease, minimal, lung Medial calcification, focal, minimal, pulmonary artery, lung
79-17B	Chronic respiratory disease, minimal, lung, rat Congestion, minimal, lung
79-17C	Pneumonia, granulomatous, multifocal, minimal, lung, rat Chronic respiratory disease, lung

PROTOCOL NO.: PEM 78-7 TABLE 14 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
 SEX: FEMALE SMOKE II

EXPOSURE: 200 MG/M<sup>3</sup>  
 AGENT: WHITE PHOSPHORUS/FELT  
 LENGTH OF EXPOSURE: 13 WEEKS  
 POST EXPOSURE: 30 DAYS

ACCESSION NO.

DIAGNOSIS

79-16A	Histiocytosis, focal, minimal, lung, rat Pneumonia, interstitial, focal, minimal, lung
79-16B	Congestion, minimal, lung, rat
79-16C	Histiocytosis, multifocal, minimal, lung, rat Lymphoid infiltrate, focal, minimal, lung
79-16D	Congestion, mild, lung, rat
79-16E	Medial calcification, focal, minimal, pulmonary artery, lung, rat
79-16F	Histiocytosis, multifocal, minimal, lung, rat

PROTOCOL NO.: PEM 78-7 TABLE 15 HISTOSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS  
SMOKE II

SEX: FEMALE  
EXPOSURE: CONTROL  
AGENT: WHITE PHOSPHORUS/FELT  
LENGTH OF EXPOSURE: 13 WEEKS  
POST EXPOSURE: 30 DAYS

Appendix F

<u>ACCESSION NO.</u>	<u>DIAGNOSIS</u>
79-18A	Chronic respiratory disease, minimal, lung, rat
79-18B	Congestion, minimal, lung, rat

DISTRIBUTION LIST 6

Names	Copies	Names	Copies
<b>CHEMICAL SYSTEMS LABORATORY</b>			
ATTN: DRDAR-CLF	1	Federal Emergency Management Agency	
ATTN: DRDAR-CLC-B	1	Office of Mitigation and Research	
ATTN: DRDAR-CLC-C	1	ATTN: David W. Bensen	1
ATTN: DRDAR-CLC-E	1	Washington, DC 20472	
ATTN: DRDAR-CLJ-R	3	US Army Research and Standardization	
ATTN: DRDAR-CLJ-L	3	Group (Europe)	
ATTN: DRDAR-CLT	1	ATTN: DRXSN-E-SC	1
ATTN: DRDAR-CLT-E	1	Box 65, FPO New York 09510	
ATTN: DRDAR-CLT-P	1	Commander	
ATTN: DRDAR-CLN	1	HQ 7th Medical Command	
ATTN: DRDAR-CLW-C	1	ATTN: AEMPM	1
ATTN: DRDAR-CLB-C	1	APO New York 09403	
ATTN: DRDAR-CLB-P	1	Commander	
ATTN: DRDAR-CLB-PA	1	USAOTEA	
ATTN: DRDAR-CLB-PO	1	ATTN: CSTE-ZX	1
ATTN: DRDAR-CLB-R	1	5600 Columbia Pike	
ATTN: DRDAR-CLB-TE	1	Falls Church, VA 22041	
ATTN: DRDAR-CLY-A	1		
ATTN: DRDAR-CLY-R	1		
AUTHOR'S COPIES: Research Division	0	OFFICE OF THE SURGEON GENERAL	
<b>DEPARTMENT OF DEFENSE</b>			
Defense Technical Information Center		Commander	
ATTN: DTIC-DDA-2	2	US Army Medical Bioengineering Research	
Cameron Station, Building 5		and Development Laboratory	
Alexandria, VA 22314		ATTN: SGRD-URD-AL	1
Director		Fort Detrick, Bldg 568	
Defense Intelligence Agency		Frederick, MD 21701	
ATTN: DB-461	1	US ARMY HEALTH SERVICE COMMAND	
Washington, DC 20301		Superintendent	
Special Agent in Charge		Academy of Health Sciences	
ARO, 902d Military Intelligence GP		US Army	
ATTN: IAGPA-A-AN	1	ATTN: HSA-CDH	1
Aberdeen Proving Ground, MD 21005		ATTN: HSA-IPM	1
Commander		Fort Sam Houston, TX 78234	
SED, HQ, INSCOM		US ARMY MATERIEL DEVELOPMENT AND	
ATTN: IRFM-SED (Mr. Joubert)	1	READINESS COMMAND	
Fort Meade, MD 20755		Commander	
<b>DEPARTMENT OF THE ARMY</b>			
HQDA (DAMO-NCC)	1	US Army Materiel Development and	
WASH DC 20310		Readiness Command	
		ATTN: DRCLDC	1
		ATTN: DRCSF-P	1
		5001 Eisenhower Ave	
		Alexandria, VA 22333	

Commander  
US Army Foreign Science & Technology  
Center  
ATTN: DRXST-MT3  
220 Seventh St., NE  
Charlottesville, VA 22901

Director  
US Army Materiel Systems Analysis  
Activity

ATTN: DRXSY-MP  
ATTN: DRXSY-T (Mr. Metz)  
Aberdeen Proving Ground, MD 21005

Commander  
US Army Missile Command  
Redstone Scientific Information  
Center  
ATTN: DRSMI-RPR (Documents)  
Redstone Arsenal, AL 35809

Director  
DARCOM Field Safety Activity  
ATTN: DRXOS-C  
Charlestown, IN 47111

Commander  
US Army Natick Research and  
Development Command  
ATTN: DRDHA-VR  
ATTN: DRDHA-VT  
Natick, MA 01760

US ARMY ARMAMENT RESEARCH AND  
DEVELOPMENT COMMAND

Commander  
US Army Armament Research and  
Development Command  
ATTN: DRDAR-LCE  
ATTN: DRDAR-LCE-C  
ATTN: DRDAR-LCM-SA  
ATTN: DRDAR-PMA (G.R. Sacco)  
ATTN: DRDAR-SCM  
ATTN: DRDAR-SCA-W  
ATTN: DRDAR-TSS  
ATTN: DRCPM-CAWS-AM  
Dover, NJ 07801

US ARMY ARMAMENT MATERIEL READINESS  
COMMAND

Commander  
US Army Armament Materiel  
Readiness Command  
ATTN: DRSAR-IRC  
ATTN: DRSAR-ISE  
ATTN: DRSAR-LEP-L  
ATTN: DRSAR-SF  
Rock Island, IL 61299

Commander  
USA ARRCOM  
ATTN: SARTE  
Aberdeen Proving Ground, MD 21010

Commander  
US Army Dugway Proving Ground  
ATTN: Technical Library (Docu Sect)  
Dugway, UT 84022

US ARMY TRAINING & DOCTRINE COMMAND

Commandant  
USAMP&CS/TC&FM  
ATTN: ATZN-CM-CDM  
Fort McClellan, AL 36205

Commander  
US Army Infantry Center  
ATTN: ATSH-CD-MS-C  
Fort Benning, GA 31905

Commander  
USA Combined Arms Center and  
Fort Leavenworth  
ATTN: ATZL-CA-COG  
Fort Leavenworth, KS 66027

DEPARTMENT OF THE NAVY

Commander  
Naval Weapons Center  
ATTN: Technical Library (Code 343)  
China Lake, CA 93555

Commander Officer  
Naval Weapons Support Center  
ATTN: Code 5042 (Dr. B.E. Doude)  
Crane, IN 47522

DEPARTMENT OF THE AIR FORCE

HQ Foreign Technology Division (AFSC)

ATTN: TQTR

Wright-Patterson AFB, OH 45433

1

Commander

Aeronautical Systems Division

ATTN: ASD/AELD

ATTN: ASD/AESD

Wright-Patterson AFB, OH 45433

1

1

OUTSIDE AGENCIES

Battelle, Columbus Laboratories

ATTN: TACTEC

505 King Avenue

Columbus, OH 43201

1

Toxicology Information Center, WG 1008

National Research Council

2101 Constitution Ave., NW

Washington, DC 20418

1

US Public Health Service

Center for Disease Control

ATTN: Lewis Webb, Jr.

Building 4, Room 232

Atlanta, GA 30333

1